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DANS L'INTÉRÊT DES RÉGIONS PEU DÉVELOPPÉES**

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**CREATION DE POINT D'EAU
A PARTIR DE L'ENERGIE SOLAIRE**

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Création de point d'eau à partir

de l'énergie éolienne

par M. GION. Ingénieur à SOGREAH. Grenoble.

Très souvent actuellement, les techniciens ont tendance à considérer l'énergie éolienne comme une forme d'énergie démodée, et en tous cas peu rentable.

S'il s'agit de capter l'énergie éolienne pour concurrencer le KWh qui peut être pris sur un réseau électrique puissant, ou pour économiser des tonnes de carburant à proximité d'un distributeur d'essence il est certain que la rentabilité de l'opération n'est presque jamais assurée.

Par contre, il est de nombreux cas où l'énergie du vent apparaît comme très intéressante, parfois même c'est la seule qui puisse être utilisée.

De nombreuses régions dans le monde, souvent arides ou marécageuses, sont démunies de lignes électriques de transport d'énergie et de voies de communication aisées. Pour ces régions, l'absence de voies d'accès faciles grève lourdement le prix de revient de la tonne de carburant (essence ou fuel) rendue sur place ; par ailleurs, la densité de peuplement souvent faible, rend difficile la réalisation d'un réseau d'interconnexion dans des conditions économiques satisfaisantes.

Or, il est fréquent de voir ces régions avoir besoin localement d'une petite source d'énergie soit :

- pour pomper de l'eau potable dans une nappe souterraine en vue de la création d'un point d'eau ;

- pour évacuer l'eau polluée d'un marécage en vue de l'assainissement d'une région insalubre.

Pour toutes ces raisons, l'installation d'un petit groupe générateur d'énergie, prenant sa source dans la force du vent, apparaît souvent comme étant une solution technique et économique très intéressante.

Le présent mémoire décrit deux exemples d'installations qui répondent à cette demande :

- Le premier exemple est celui d'un point d'eau créé à partir d'une éolienne classique pour pompe à piston, dont l'ensemble du matériel mécanique qui l'équipe a été étudié de façon à pouvoir être construit par de petites industries locales.
- Le second exemple est celui d'un point d'eau équipé d'une éolienne à trois pales dont la puissance peut atteindre 28 KW. Machine de conception moderne et pouvant convenir pour des installations déjà importantes.

Le mémoire aborde pour terminer, très sommairement l'aspect de la rentabilité de ces installations.

1) Point d'eau équipé d'une éolienne de petite puissance -

La première installation décrite dans ce mémoire est celle représentée par la photo n° I qui est celle d'un point d'eau créé pour une région d'élevage et équipée de toutes les installations permettant :

- de pomper l'eau dans la nappe qui se trouve à des profondeurs pouvant atteindre 120 m
- de stocker un certain volume d'eau
- de permettre aux hommes de s'approvisionner en eau potable
- de maintenir un niveau d'eau constant dans des abreuvoirs destinés au bétail.



Photo n° I

L'éolienne, de conception classique pour pompe à piston, a un diamètre de roue qui peut varier entre 3m et 5,50m.

La pompe à piston pour puits profonds a des garnitures de piston spécialement étudiées pour éviter les coincements du piston.

Une disposition particulière des différents niveaux au refoulement de la pompe permet d'éviter la présence sur la tête de pompe d'un presse-étoupe, organe qui, sur ce genre de machine, demande un entretien fréquent.

L'ensemble éolienne-pompe est accouplé au moyen d'un levier spécial qui permet de faire varier la course de la pompe tout en gardant la même course à l'éolienne.

Cette disposition permet d'ajuster la puissance demandée par la pompe au régime des vents de la région où se trouve l'éolienne. De plus, pour une même installation, elle permet très rapidement de faire varier la course de la pompe en fonction des variations annuelles du régime des vents.

La pompe refoule dans un ensemble de réservoirs permettant d'accumuler un certain volume d'eau pour passer les périodes sans vent.

Des réservoirs, partent plusieurs conduites :

- une, destinée à l'alimentation d'une borne fontaine pour les usages des hommes
- une, destinée à l'alimentation d'abreuvoirs à usage du bétail. Afin d'éviter les pertes d'eau, les abreuvoirs sont alimentés par l'intermédiaire d'un obturateur à niveau constant placé dans un regard fermé et qui maintient le niveau d'eau suffisamment bas pour éviter les déversements.

La quantité d'eau qui peut être pompée avec ces installations est évidemment variable avec le diamètre de la machine, et la profondeur du puits. A titre d'exemple, un point d'eau équipé d'une éolienne de 5,5m de diamètre de roue, dont la pompe puise dans une nappe de 100m de profondeur, est capable de fournir annuellement 4.500 m³ d'eau, s'il est situé dans une région faiblement ventée.

Ces installations ne nécessitent qu'une surveillance et un entretien réduit, cependant il y a lieu de prévoir une visite tous les deux ou trois mois par une équipe spécialisée. Pour l'entretien de ces installations, l'idéal est d'en installer dans une même région un nombre suffisant (20 à 30 au moins) de façon à avoir l'utilisation à plein temps d'une équipe spécialisée, convenablement outillée.

Pour terminer avec cet exemple d'installation qui a déjà été réalisé en de nombreux exemplaires, nous soulignerons que la conception mécanique de toutes les parties de l'équipement a été entièrement étudiée en vue de faciliter leur fabrication par des ateliers relativement peu outillés.

Cette disposition permet, à un pays encore peu industrialisé pour lequel la réalisation de tels points d'eau est souvent très nécessaire, d'envisager la construction par des artisans locaux de 80 à 90 % de l'équipement mécanique.

2) Éolienne de plus grande puissance à hélice

Avec les installations précédemment décrites, il est difficile de dépasser pour la roue éolienne des diamètres de 6 à 8 mètres. Ceci limite la puissance de ces installations à environ 2 à 3 C.V. pour un vent moyen.

Afin d'obtenir des puissances supérieures, il faut faire appel à un autre principe de roue éolienne : une hélice à trois pales par exemple.

Le schéma n° II représente une installation de pompage équipée avec une éolienne à hélice de 13m de diamètre.

L'éolienne est constituée d'une hélice à trois pales à pas variable. Les pales, de conception très particulière sont réalisées entièrement en plastique armé au verre.

L'hélice entraîne un multiplicateur de vitesse à train conique hélicoïdal, qui permet de sortir la puissance recueillie sur un arbre vertical descendant dans l'axe du pylône. Cette disposition permet d'ac-coupler à l'éolienne n'importe quel organe récepteur d'énergie (pompe, dynamo, alternateur...) placé au sol ou dans le pylône.

Le fonctionnement d'une telle installation est entièrement automatique, quelle que soit la force du vent la machine continue à tourner à sa vitesse de régime, grâce au réglage automatique du pas de l'hélice par un dispositif d'embielage équilibré par des ressorts.

Pour les petits vents, la forme des pales a été choisie de façon à fournir à la machine un fort couple de démarrage. Ceci permet à une installation normale de commencer à tourner pour des vents de l'ordre de 3 m/sec. dans l'axe de l'hélice.

Ces machines permettent d'obtenir des puissances relativement importantes.

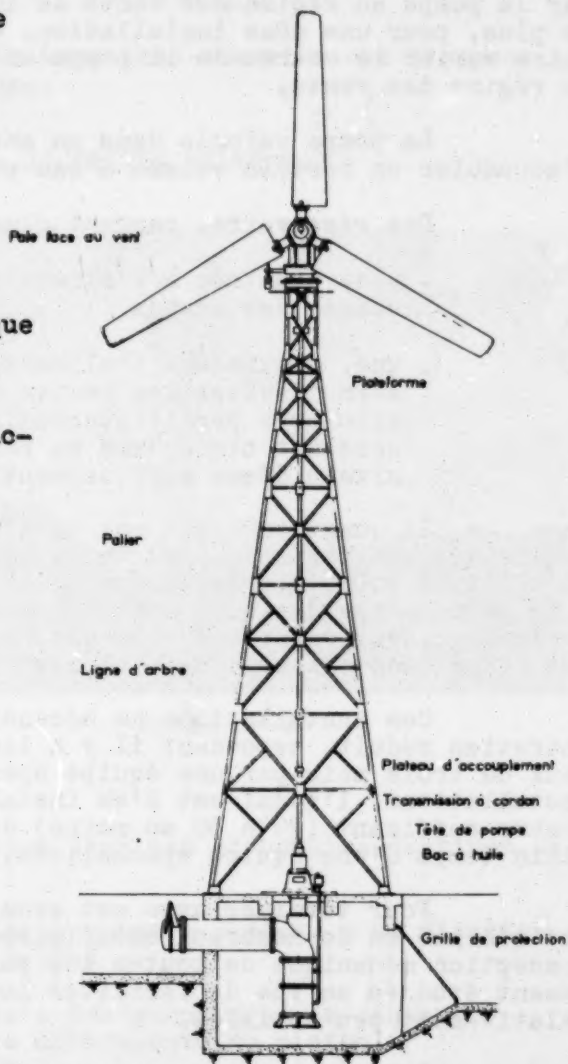


Schéma n° II

C'est ainsi que les puissances obtenues pour un vent de 8 m/sec. atteignent :

- 6,4 KW pour une éolienne de 8 m de diamètre -
- 10,3 KW pour une éolienne de 10m de diamètre -
- 18 KW pour une éolienne de 13m de diamètre -
- 28 KW pour une éolienne de 16m de diamètre -

La conception de l'éolienne est particulièrement bien adaptée à l'entraînement d'une pompe, qui peut être accouplée :

- soit directement, c'est le cas du schéma n° II (accouplement en direct d'une pompe hélice)
- soit par l'intermédiaire d'un multiplicateur de vitesse à courroies lorsque la vitesse de l'axe vertical de l'éolienne est trop faible pour la pompe.



Photo n° III

Pour le pompage de l'eau au moyen de ces machines, nous citerons deux utilisations possibles :

• La création de point d'eau de puissance assez importante. Dans ce cas la pompe devra le plus souvent aspirer dans une nappe profonde. L'éolienne entraîne une pompe centrifuge à axe vertical pour puits profond qui devra toujours être accouplée par un multiplicateur de vitesse.

• L'assainissement de régions marécageuses. Dans ce cas la pompe sera le plus souvent une pompe hélice à faible hauteur de refoulement. Notons que pour cet usage l'irrégularité de la puissance du vent n'est pas une gêne, le volume d'eau du marécage faisant lui-même volume tampon.

La photo n° III donnée à titre d'exemple est celle d'une station d'assainissement.

Cette station est équipée d'une éolienne de 13m de diamètre qui entraîne une pompe hélice de 700 mm de corps.

L'installation, pour un vent de 8 m/sec, est capable de débiter 1 m³/sec lorsque la hauteur totale de refoulement est de 1m. Elle fonctionne 5.000 heures par an, dont environ 2.500 heures à pleine

puissance, et est capable de pomper annuellement un volume total d'eau d'environ 15 millions de m³.

3) La rentabilité des installations décrites

Il n'est pas possible ici de rentrer dans le détail d'une étude économique qui serait fort complexe, et dont les données varient avec chaque pays.

Nous dégagerons simplement quelques lignes directrices permettant de situer les cas où l'énergie recueillie avec ces machines est économiquement intéressante par rapport aux autres formes possibles d'énergie.

En règle générale, le KWh produit à partir de l'énergie éolienne par les installations décrites, est une énergie chère si on le compare brutalement au KWh tiré d'un réseau électrique puissant. Il ne faut en effet pas perdre de vue les frais d'installations d'une éolienne qui sont assez élevés, et ce coût élevé de l'investissement de départ atténue considérablement l'intérêt de la gratuité du vent.

Cependant, il est de très nombreux cas pour lesquels l'installation d'une station de pompage entraînée par éolienne devient économiquement intéressante.

En règle générale, s'il s'agit de créer un point d'eau dont la consommation moyenne annuelle d'énergie reste inférieure à 100.000 KWh, on pourra dire que :

1) l'énergie éolienne sera plus intéressante que l'énergie électrique prise sur un réseau, s'il est nécessaire, pour alimenter la station de pompage en énergie électrique, de créer une ligne spéciale de plus de 20 km.

2) l'énergie éolienne sera plus économique que l'énergie électrique, si le KWh électrique rendu au point d'eau (compte tenu de l'amortissement de la ligne électrique) coûte plus de 20 N.F.

3) l'énergie éolienne sera plus économique que l'énergie obtenue à partir d'un moteur à essence ou à fuel, chaque fois que le coût de la tonne de carburant, rendue à l'endroit du point d'eau, sera supérieure à 300 N.F.

L'examen de ces marges de rentabilité, indiquées bien sûr à titre d'ordre de grandeur, montre qu'il existe dans le monde de nombreuses régions, suffisamment ventées, pour lesquelles l'éolienne est une solution économique à la création de points d'eau.



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**UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS**

Agenda Item : A.2

Hungary

**SOME ASPECTS OF INTEGRATED RIVER BASIN DEVELOPMENT
IN LESS DEVELOPED AREAS**

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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)



NOTES

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SOME ASPECTS OF INTEGRATED RIVER BASIN DEVELOPMENT IN LESS DEVELOPED AREAS

by

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Introduction

1. For the multi-purpose utilization of river basins situated in economically less developed areas, different preparation methods and implementation schedules are desirable from several aspects as for the development of river valleys in more advanced territories. A number of important differences can be established which are to be considered in the course of planning. It is quite obvious that the guiding principles as regards the integrated river basin development should be primarily drawn from experiences and results afforded by realizations in more advanced areas. The conclusions, however, will be correct only, if the special aspects are clearly established which are to be taken into account when a plan for less developed areas is to be prepared. These differences are pointed out in brief in the following. Further an example of a master plan developed for an entire country will be given, and finally some conclusions will be drawn. Questions of financing are not dealt with in the paper.

Main Differences in Physical and Social Conditions when Comparing Plans for Advanced and Less Developed Areas

2. Natural conditions in less developed countries are explored to a lesser degree, even the important physical data may be completely lacking. This disadvantage, however, should be made up at least to a degree that the preliminary over-all plan of the integrated utilization of the river basin could be prepared with satisfactory accuracy, or in a way that the economical conclusions drawn from the plan should be correct in their principles. Therefore, the most important observations, measurements, explorations and scientific researches should be performed at an increased pace, in order to elaborate the studies relating to the distribution of water resources and the storage thereof within relatively short time, yielding the balance of supplies and demands. This aim, however, can only be achieved if exploration and research work is carried out by multi-phase development. In other words, this is to be understood that any branch of research should not be developed in the first stage to the degree necessitated at

a later stage for the formation of the final plan, since this would involve excessive time and cost, hindering the preparation of a preliminary plan necessary for the decisions to be made. On the other hand attention should be paid that, in any stage of planning, no branch of the necessary investigations should be overdeveloped at the expense of other branches. Last but not least the most important point, the relative urgency of research work and consequently the resulting order of the same should be mentioned. In this respect the professional prejudice of the representatives of the individual branches of science must not prevail, and the realization of this aspect rests with the group of experts directing the work. It is easy to give an example: it is to be avoided to perform a more detailed soil - mechanical or geological investigation at the possible sites of major installations as long as the informative magnitude of water resources and the estimated value of the water balance is not available. Thus, the precedence of informative meteorological, hydrological and topographical investigations /surveying/ becomes obvious. Furthermore, within hydrological investigations the preparation of detailed measurements should not be commenced, before on basis of precipitation data and informative measurements approximate hydrological pattern of the river basin is obtained. This will notably decide upon the density and type of the observation network to be established at a later stage. Attaining, however, a certain degree of hydrological exploration, it is desirable to perform informative geological, pedological and other investigations in order to obtain a clearer picture to what degree the utilization of available resources is permitted by other natural conditions /e.g. the reasonable height of large dams and the storage capacity thereof possibly permitted by topographical and geological conditions/. The time of preparing the preliminary over-all plan to be submitted to the government for their first decision should not be too long and the cost estimate thereof is also limited. Otherwise government factors would refrain from the preparation of the same; should it become manifest in the course of work that the preparation of the plan is far too prolonged or would involve a considerably greater investment as envisaged, the planning work altogether may come to a standstill. Annex I of the United Nations, Department of Economic and Social Affairs publication, No. E/3066 gives a very valuable guide to the organization of basic research /1/.

3. Protection works against damages caused by water are or rather were more or less completely realized in advanced areas usually a long time ago, since one of the most important prerequisites of economical development in general is that settlements, industrial plants, mines, communication networks and agriculturally valuable lands should be protected against inundations, logging waters, excessively raising groundwater, and that marshlands should be drained. In addition the various utilization of waters /irrigation, navigation, hydroelectric power production and possibly pumped storage, industrial and domestic water supply, fishponds, use of medicinal and mineral waters, recreation and sports/, further soil conservation, protection against erosion, and reforestation, etc. was observed. In highly developed areas at present waste water and sewage treatment constitutes in general the greatest task.

4. In the river valleys of less developed areas mainly the signs of protection against water damages /chiefly flood control/ can be recognized, and these are mostly of local character. It is quite natural, however, that less developed countries being already in a relatively more advanced situation, based on ancient traditions and newly established installations, smaller or greater irrigation systems came into being and simple local solutions of supplies meeting other demands can also be found.

5. It follows from the foregoing that development recommendations prepared for less developed countries should comprise the plans to meet the requirements of basic flood protection and drainage, and those of water projects for a more advanced economy as well. Thus the plan should enable to make up for the time lost due to lesser development, which imposes great responsibility on those preparing the plans, since the possible economical and social development should be reckoned with with the utmost foresight.

6. It is irrefutable at the same time that in less developed areas physical and social inhibitions are smaller /less developed settlements, small density of population in individual valleys, scarce communication network, lack of major structures, etc./ affording greater liberty to experts and designers. From this statement it also follows that, in general, more alternatives can be elaborated as compared to those regarding the further development of more advanced river valleys. Besides the alternatives on major installations arrangement may differ to a greater extent from each other. These circumstances, however, are also of adverse effect, making more difficult and causing delay in government decisions.

7. In the various phases of planning and implementation more modifications and alterations must be reckoned with in less developed areas as compared to those encountered in advanced areas. In the former case, notably, at the beginning of planning less accurate data are available as regards the physical, social and other conditions of the river basin.

8. Besides technical and scientific aspects the type and general arrangement of major hydraulic structures in less developed countries may be strongly influenced and modified by social conditions, primarily by skilled labour available and the number of qualified hands. Thus, e.g. the lack of trained workers may necessitate that dams should be built as earth dams or rock-fill dams at sites, where, otherwise the erection of a concrete gravity dam would be indicated. Transport facilities exert the same influence.

9. The requirement, that a satisfactory utilization of the first project to be built in the framework of the integrated river basin development plan for less developed countries should be commenced after the commissioning thereof, calls for special foresight. Thus, e.g. in case of installing an irrigation project every preparation should be done for the efficient operation at the farms to be supplied with water. In this respect the following main facilities should be provided for: the internal technical installations for irrigation and drainage, agricultural equip-

ment and materials, adequately trained agricultural hands. Further development has been frequently frustrated by the lack of necessary equipment and special knowledge. Failure in many instances, notably, was not attributed to the defective operation due to lack of sufficient knowledge, but to the incorrectness of the scheme. Instances can also be found where, because of failures occurred, due to miscarried irrigation, the futility of irrigation had been concluded, even irrigation had been discontinued. Such phenomena may completely paralyze the implementation of the integrated river basin development on account of the extremely unfavourable propagative and psychic effect exercised both on the population and responsible government officials. The urgency of the realization of the educational programme cannot be overemphasized. It is aptly stated in the United Nations expert's report already quoted: "Pilot schemes and demonstration farms should be developed where - ever feasible in order to show what new possibilities may arise once the waterworks come into operation." /See /1/, par. 44, p.14/

10. In the course of developing irrigation projects, special care should be given to the development of drainage as well, lest logging waters on ~~or~~ salination of irrigated areas should occur. This directive applies also to more advanced territories, but, since drainage thereof had been commenced in olden times preceding the preparation of the up-to-date integrated development plan, the solution of the problem becomes simpler: the novel task is not more than the extension of the already existing drainage system to a lesser or greater degree.

11. It should be eventually stressed that between countries termed collectively less developed areas, there is a gradual transition towards the more advanced ones, moreover, even within one country river valleys exploited to different degrees can be found. In the course of organizing research work and the preparation of the development plan it is of high consequence to what degree the river basin concerned is developed at that time.

12. In less developed areas research institutes and design bureaus to be entrusted with the elaboration of the final development plan and detailed designs are generally absent, or if any, they are usually working in narrow frames. The organizations existing in more advanced countries can be more easily developed for the solving of some new tasks.

Utilization of the Experiences Gained in Advanced Areas

13. With a novel task occurring in less developed areas, the experiences gained with river basin schemes already implemented or under way in various parts of the world, should be made use of to advantage. Obviously commissioning governments and experts entrusted with planning work are primarily interested in developments realized in areas situated geographically near or having similar climatic conditions. However, to achieve optimum solution it is most desirable to extend studies to other remote river valleys having possibly entirely different climate, if similarity in some respect can be found therein. From seemingly remote cases some use-

ful experiences may be gained or valuable conclusions and lessons can be drawn in the following problems:

- measurement procedures and instruments for the exploration of physical conditions, establishment of observation net - works,
- methods for the collection and evaluation of relevant data,
- organizational structure of research work, laboratories,
- methodological problems of scientific research,
- in individual branches of research, where similarity between the river basin to be developed and that under study is noticeable, the adaption of the final results is possible as well,
- design procedures, norms, standard specifications, standard designs,
- methods and organization of construction, mechanization,
- adaption of operation experiences,
- financial problems and methods of economic evaluation,
- education methods and training programme,
- possible examples for the collaboration between two or several countries,

and finally the methodology of the preparation and multi-stage development of integrated river basin planning.

14. Several multi-purpose water management plans have been implemented all the world over, about most of which - in detail as well as comprehensively - numerous descriptions can be found in books and periodicals, therefore the author dispenses with the enumeration thereof. Also summarizing studies have been published of which that of Kanwar Sain [2] and K. L. Rao [3] are mentioned.

15. Considerable assistance is rendered for the experts by the regional conference of the UN ECAFE organization [4] and the manual [5] published by the same. Also the publication of the said UN Commission dealing with flood protection as a problem of special importance [6] or those enlarging upon the present state multi-purpose development merit attention [7], [8].

16. It cannot be the intention of the author to review the international schemes within the frames of the present brief study, nevertheless he would wish to present just one example, notably the present state and development plan of Hungary's water management.

Development and Present State of Water Management in Hungary

17. To properly understand Hungary's water resources development plan, the historical antecedents as well as the present state of water projects should be known [9], [10].

18. Of Hungary's territory of 93,000 sq. km, some 24,000 sq. km, roughly one-fourth of the entire area, is protected against inundations caused by floods by levees. The overall length of protection levees amounts to about 3900 km. This work was begun as early as 1846.

19. River regulation work on Hungary's rivers is aimed at ensuring the unobstructed travel of floods, ice and sediment load, further at the creation of permanent navigation depth over major rivers. River training work in Hungary had been started in close connection with flood control. The big bends of the Middle-Danube have been cut through at 15 places in the period between the years 1820-1832, by which a shortening of 96 km ensued. Similarly regulation work on the Tisza River was initiated. The length of the river had been shortened by 112 cuts by 454 km in the period between the years 1840-1870. The travelling time of floods has been abated thereby from some 40 weeks to about 8 weeks. River training in Hungary extends at present to a 2400 km long river stretch of which 1300 km is navigable. The overall length of the regulation structures is 850 km.

20. Drainage control of the areas protected from the inundation of floods followed closely river training and levee construction. Prior to the development of drainage control, large areas were covered by logging waters during wet periods. Drainage control has been achieved by the following installations: a canal system of an overall length of 27,000 km, 252 pumping stations with an overall delivery capacity of 440 cu.m/sec, further 900 portable pumps having an aggregate capacity of about 230 cu.m/sec, about 400 pipe culverts and inlet gates crossing the flood protection dykes and some 20,000 small hydraulic structures in the canals.

21. The magnitude of the irrigated area at present amounts to 186,000 hectares from which 50 per cent is supplied by sprinklers. Some considerable results had been attained by irrigation. In irrigated areas an increase in crop yield from 50 to 150 per cent or even more could be achieved, as compared to that with dry farming.

22. Pisciculture is carried on in artificial fishponds for over a century. Fishponds have an aggregate surface area of 22,700 hectares at present.

23. Hydroelectric power generation is developed up-to-now on a low scale only, viz. at stations built on smaller streams. The high-capacity Danube project is under preliminary planning at present.

24. Some 66 per cent of the population of about 10 million is supplied with good quality drinking water. The aggregate capacity of waterworks serving the purpose of drinking water supply amounts to 820,000 cu.m/day, and of industrial water supply plants to 4.2 million cu.m/day. The most rapid development in the field of waste water and sewage treatment was witnessed during the last decade.

25. Eventually also works carried out over the entire territory of the country in the last fifty years in the field of the regulation of small water-courses, dewatering of marshlands, regulation of lakes, gully control and tile drainage should not be omitted.

Master Plan for Water Resources Development in Hungary

26. The first approach of the Master Plan for water resources development in Hungary had been elaborated on the proposal and under the guidance of the author between 1952-1954 /11/. The Plan had been supervised by the Hungarian Academy of Sciences and discussed on a conference of the same. The summarization of the Plan consists of ten parts /Vols. I-X/, ten supplements /maps, diagrams, etc./ and a synthesis /of two volumes/.

27. Special attention is paid to irrigation projects, and to avoid conflicts between water needs and available resources, even if the conflicts are of temporary nature, the "concept of tolerance" suggested by the author has been used. By this method the reasonably permissible reduction in specific water supply as related to optimum demand, is calculated for various plants to be irrigated. According to investigations in this field it could be stated that economical optimum can be attained, if irrigation projects will be designed for discharges which are available at a probability of 80 per cent, i.e. in 80 years from among 100. If such an assumption will be accepted, decrease in crop yield, even in most arid years, will not exceed the value of 10 per cent as compared to the optimum yield, and a multi-annual average loss in crop yield will be as much as 1 per cent only.

28. In the synthesis of the Plan a programme is given for explorations and research work to be carried out in the interest of further development of the plan.

29. The more detailed and improved development of the Master Plan being in progress under the guidance of the National Water Authority, will comprise 20 parts and accordingly will be summarized in 20 chapters /each of them compiled in one or more volumes/ as follows: I Aim and importance of water management in the national economy; II Natural conditions, available water resources of the country; III Flood control, control of lakes and river training; IV Drainage; V Improvement of small water - courses and control of the catchment area thereof; VI Irrigation; VII Pisciculture and fishponds; VIII Domestic and industrial water supply; IX Sewage of settlements and waste waters of industrial plants; X Protection against pollution; XI Waterways and ports; XII Reservoirs and multi-purpose use of stored water; XIII Utilization of mineral, medicinal and thermal waters; XIV Recreation, sports, nature conservation; XV Major hydraulic installations; XVI Questions of international nature; XVII Water balance of the entire country; XVIII Other problems connected with water management; XIX Relationship between development of water resources and other branches of national economy; XX Summary.

30. Since, in some regions of the country, surface water resources and storage possibilities as well are rather limited, high-degree utilization of groundwater resources, mainly by means of tube wells is envisaged. This aim, however, constitutes a considerable task for the Research Institute for Water Resources to establish the possible maximum yield obtainable from groundwater with -

out the hazards of non-permissible, even dangerous drawdown of the groundwater table. Therefore, groundwater table observations, pumping tests and mapping of groundwater conditions have been very carefully performed during the last decade, and research work on groundwater is even currently in progressive development.

31. To economize on irrigation water, i.e. to reduce specific water yield, a vigorous spreading of the sprinkling method is aimed at. The participation of sprinkling in the total irrigation, related to the irrigated areas, will be increased from the current value of 50 per cent /see par. 21/ up to 60 per cent even as soon as by 1965.

32. Economic evaluations are given separately in the individual chapters, based upon rough estimates of the investment and operation costs.

33. A rough approximation of cost allocation is attempted for the major installations of multi-purpose character.

34. The Plan provides for a development of 15-20 years or, in some cases, even for a longer time in the future.

35. More detailed Regional Plans will be developed from the Master Plan which work is already in progress at present. The boundaries of the so-called regions do not coincide with the watersheds in many instances, but are in conformity with some directives of econo-geographical nature.

Conclusions

36. On basis of the expounded general considerations, the numerous well-known international river basin plans and the results of the implementation thereof, further on the strength of direct experiences gained with the development in Hungary, the author feels encouraged to draw some conclusions which, possibly, may be considered in the further investigation of the problem in question.

37. Exploration, research work as well as the preparation of the integrated plan should be performed by successive approximation in several phases and in a proportionally progressing manner.

38. Prior to the realization of the first step, it is advisable to reconnoitre the river basin developments and national master plans already implemented or under way in broad field, in order to establish the factors on basis of which, due to the similarity thereof, adaptation appears to be indicated. Instances can be found, when the survey of some larger area unit of the world may permit the drawing of highly useful conclusions [127].

39. Should alternative possibilities for the basic solution emerge in excessive number, the informative elaboration of the same must not be refrained of, not even in the case when the work would involve great efforts. This aspect cannot be stressed enough, since the insufficiently clarified counter-alternatives usually

"haunt" a long time, and the reappearance of the same at a later date may completely paralyze the designing work and even the realization of the scheme. The number of the alternatives, of course, assuming careful comparison, must be reduced according to possibilities in the course of the progressing elaboration of the plan, otherwise, having reached a certain degree, too many alternatives may render the work too cumbersome and involved, resulting even in a complete failure.

40. Since the preparation of the plan is a lengthy operation, it is desirable to select the major structures, if any, in the course of elaboration already, which will fit to any of the development alternatives considered. By way of such earlier realizations it becomes possible to benefit from the income of individual hydraulic installations in the course of planning already, knowing at the same time that the projects concerned will form an inherent part of the final over-all plan. Installations put into operation realizing the hopes fostered will give financial support and exert a marked moral effect on the efficient continuation of the planning work. /Therefore, it is not advisable to wait for the realization so long as the "perfect plan" is prepared, not to mention that no such plan ever exists! /

41. The plan should be broken down to project units and should be executed in such steps that the individual installations economically function, if possible immediately after their commissioning. In other words installations becoming profitable in co-operation with structures envisaged to be realized only considerably later, should not be constructed prematurely.

42. Related branches should be developed most closely /irrigation with drainage, water supply with disposal of sewage and industrial wastes/.

43. Besides requirements and economic evaluation, development programme is strongly influenced by natural conditions and engineering principles the negligence of which may even lead to possible disasters. Some principles to be observed are e.g. that watershed control and storage reservoir construction should be commenced from upstream, whereas that of river training installations should be proceeded from downstream position in upstream direction.

44. In the course of economic investigations, when listing the benefits and disadvantages, it will prove useful to consider quantitatively also factors of minor importance, since the summation thereof may result in substantial changes of aspects. /Thus, e. g. when evaluating the significance of a river canalization scheme, it is desirable to accurately compute the savings in travelling time and fuel consumption of the vessels, obtainable by the possibility afforded for navigation over an impounded stretch/ [137].

45. For the cost allocation of multi-purpose installations numerous computation methods are known [147, /157, /16/, which may frequently lead to highly differing results. It is advisable to conduct comparative investigations and to suggest a uniform method for the economic evaluation of integrated river basin development.

46. When elaborating the integrated river basin development plan, or at the preparation of a national master plan for any country, great care should be exercised not to fix detail solutions, lest they become "verities engraved on paper", obstructing the use of scientific and technical advance to be achieved at a later stage.

47. Eventually attention should be drawn to the fact that the realization of an integrated development constitutes a most multifarious task, comprising also numerous questions outside the domain of water management, which are not of inferior import as compared to those discussed before. In the present study the author considered even the mentioning of the latter beyond his scope of work, in order to better elucidate the selected aspects within the limited space.

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**UNITED NATIONS CONFERENCE
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**Economic Commission for Asia
and the Far East**

**UTILIZATION OF WATER RESOURCES
IN MONSOON AREAS OF SOUTHEAST ASIA**

**By Bureau of Flood Control
and Water Resources Development,
ECAFE, Bangkok**

Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

NOTES

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UTILIZATION OF WATER RESOURCES IN MONSOON AREAS OF SOUTHEAST ASIA

by

Bureau of Flood Control and Water Resources Development
ECAFE, Bangkok

I. Pattern of water use in rice culture in South-East Asian countries

1. According to our recent studies on the utilization of water resources in the monsoon areas of south-east Asia, it can be said that, in general, the present pattern of utilization of water resources has been developed to suit the living conditions of the people in this region.

2. In a report presented by Mr. G.P. Jamme (BTAO expert) in 1959 to the Committee for Coordination of Investigations of the Lower Mekong Basin, he observed that, if the Mekong Committee, which is currently undertaking the investigations of the Lower Mekong Basin, wished to change the pattern of floods by constructing dams on the upper part of the Mekong river for power development, irrigation, flood control and so on, it would also be essential to introduce a new pattern of rice culture adapted to the new condition created as a result of the development of the basin. This is because today, in the Mekong delta, some fourteen species of rice are well distributed throughout the delta region adapted to the present natural conditions of flooding, such as the rate or speed of inundation, date, depth and duration of the flood and so on. Also, in the case of these deltaic areas, inundation itself has kept up the fertility of the soil for centuries.

Maximum yields as verified by the Indo-China Rice Office^{1/}

	Varieties	Yield (kg/ha)
Floating		1,304
Semi-floating		1,800
Single-transplanting	Early season	1,889
	Mid-season	2,465
	Season	2,337
	Late season	2,361
	Early season	2,231
Double transplanting	Mid-season	3,065
	Season	3,059
	Late season	2,749
		1,639
Land from which flood water has receded		
Dry land		1,200

^{1/} Report No. TAA/AFE/7, prepared for the Committee for Co-ordination of Investigations of the Lower Mekong Basin by Mr. G.P. Jamme.

3. It is also reported by SOGREAH recently in its study on the Battambang tributary project of the Mekong scheme that the varieties of rice now grown in the Battambang region, in southwestern part of Cambodia, are long cycle rice, with a not too variable date at blossoming. The quality of long cycle rice is generally not so good; it is rather breakable, and the yield is so poor that it has been suggested that to improve the quality, it is better to replace this variety with shorter cycle rice and to use fertilizer. In attaining this objective, it is also pointed out, the farming operations could easily be spread over three months. This will also make it possible to spread out the maturation and harvest period more satisfactorily. Thus from time immemorial, the present day rice culture has been developed, adapted to the natural environment. Therefore, in order to establish more efficient rice culture for the region, it is obviously necessary to build up a new environment suitable for a new culture.

4. Rice is the staple food in southeastern Asian countries. Rice fields occupy the major portion of cultivated land and rice culture has followed a traditional pattern for many centuries. According to recent statistics concerned with rice culture in Thailand, around 60 per cent of the total arable land is cultivated as rice fields and nearly one-half of the rice fields are located in Central Thailand in the Chao Phya River basin where 58 per cent of the total rice is produced. In an analysis of statistical data concerned with rice production, it is reported that the variation in production since 1939 to 1944 ranges to 31.1 per cent of the average and especially in the case of Central Thailand it extends to 38.8 per cent, and when limited to Chao Phya deltaic area, the figure becomes approximately 60 per cent. It is expected that the rate of yield of the variety commonly grown is well correlated to the highest water stage of the Chao Phya River in any year. The average of annual maximum water stage recorded during the past 120 years of Chao Phya River at Ayuthaya was 3.65 m in gauge reading, while the maximum observed was 5.23 m in 1831 and the lowest was 2.30 m in 1919. The yield of rice was rather stable during the years of high water stage of between 3.50 m to 4.20 m, but there appeared clearly a decrease in yield in the years when the high water stage was higher or lower than the above figures. These facts also suggest that the present day rice cultivation has been built up basically to conform to the conditions bestowed by nature.

5. These are the facts we are now facing in the course of economic development in this region. The author would like to point out that the hydrometeorological condition is one of the most important elements which brought about the present day pattern of rice culture in the southeastern Asian countries. We should note that this is making it difficult to introduce new patterns of rice culture to meet the production requirements of to-day.

II. The flow regime of rivers in southeastern Asian countries - Our recent experiences in the field of hydrology in this region

6. Some very interesting and pertinent facts are revealed by recent studies in the field of hydrometeorology in this region. A few examples such as the Mu River in Burma, rivers in the northeastern part of Thailand and in the western part of Cambodia, are discussed in the following paragraphs.

7. Records of the Mu River discharge were maintained at Kabo weir from 1906 to 1941. The records were started again in 1946 and have continued until to-day with the exception of 1949. The Mu River is a tributary of the Irrawaddy River and

is located in Central Burma. Kabo weir was built early in this century to divert water for irrigation. The total catchment area above Kabo is about 12,400 km². Unfortunately the discharge records from 1906 to 1941 kept in Burma were lost during the war years. As such records are very useful for correlating river discharge with rainfall records, we are now trying to locate the missing records for use in connexion with the formulation of a plan for the development of the river, but have not yet been successful. According to the existing records of 15 years, the maximum flood recorded was 7,700 m³/sec which occurred in 1956 and it was mentioned that another large flood which occurred in 1928 was 5,300 m³/sec. As for the discharge during the dry season, it has dropped to as low as 1.3 m³/sec. nearly every year and the lowest recorded was 0.8 m³/sec. The recorded annual flows at Kabo weir for the period 1946 to 1956 were as follows:-

Maximum (1956)	10,686 million m ³
Average	4,257 million m ³
Minimum (1951)	2,160 million m ³

8. Rainfall records in the Mu River basin were maintained from 1901 to 1940 at eleven stations. All recordings, however, were stopped from 1941 to 1945 because of the Second World War. Maintenance of records was resumed in 1946, but only at the stations below the Kabo weir, and has continued to date with the exceptions of 1947 and 1948 for which there are no adequate records. Rainfall readings at the stations above Kabo weir stopped in 1941 and have never been resumed. According to the records maintained at Kabo during the past forty years, the maximum rainfall was in 1928 which was 1880 mm and the minimum of 670 mm occurred in 1920, the average is 980 mm.

9. This is a rough picture of the hydrological status of the Mu River basin. It can be noticed at a glance that these figures vary widely; the ratio of the maximum and the minimum discharge rises to nearly 9,000, and that of the annual flow is around 4.9 while that of the annual amount of rainfall is around 2.9.

10. We have some data on the hydrological status of northeast Thailand prepared by a Japanese team investigating the potential Nam Gam project for the Mekong Committee. In this region, there is a lake called Nong Han and the records of the lake level have been maintained by the Department of Fisheries since 1949. The total catchment area above Lake Nong Han is estimated around 1,460 km². The annual inflow to the lake, which means the out flow from this basin, was calculated by using the recorded lake levels and gives the maximum annual inflow to the lake of 945 million m³ in 1953 and the minimum of 339 million m³. Converted to terms of depth per unit of catchment area, the maximum inflow in 1955 was 653 mm per km² and the minimum 230 mm per km². As for rainfall, one station, which was established in Sakon Nakorn located near the lake, has a record of 13 years which shows the maximum annual precipitation of 1,704.1 mm in 1953 and the minimum of 991.9 mm in 1955. Since that time three additional rain gauges were set up in this basin. Using these records, the annual rainfall for the entire basin was

calculated in the following tabulation. The computed run-off coefficient of the entire basin shows rather wide differences, covering a range from roughly 40 to 20 per cent. Some difficulties were also experienced in correlating these values of run-off coefficient and annual rainfall.

Annual Inflow and Outflow Coefficient of Lake Nong Han^{2/}

Year	Annual inflow to Lake Nong Han (Aug. to Dec.) mm	Annual precipi- tation estimate for entire basin mm	Estimated outflow coefficient for entire basin %
1949	559.1	1,701.0	32.86
1950	572.6	1,533.4	37.34
1951	502.2	1,364.9	36.79
1952	526.7	1,347.9	39.08
1953	653.6	1,638.9	39.88
1954	373.6	1,408.7	26.52
1955	230.5	977.3	23.59
1956	512.7	1,533.3	33.44
1957	275.3	1,340.6	20.54
1958	319.3	1,356.1	23.55
1959	270.7	1,168.7	23.16
1960	408.4	1,689.3	24.18
1961	569.1	1,775.7	32.04

11. Measured stream flow in the Nam Gam basin is only available for 1961 at the proposed Nam Pung dam site. Measurements were taken by the Government of Thailand from which the following tabulation was compiled. From these figures, it can be said that the run-off status of the river varies with the date of rainfall. For the early monsoon season, even under rather heavy rainfall, less than 10 per cent of precipitation runs into river. In the latter part of the monsoon season, the run-off coefficient rises up to nearly 60 per cent. This analysis shows that even the total amount of precipitation may be nearly the same, there can be a wide variation in rate of run-off or stream flow from the drainage area depending on the changing of pattern of rainfall. This makes it difficult to estimate the flow status from rainfall records.

^{2/} Interim Report on Preliminary Studies of Nam Gam Project prepared by Japanese Government Investigation Team on the Nam Gam Project, August 1962.

Date	Rainfall (mm)	Run-off coefficient (%)		
		Base flow	Surface flow	
29 Sept. - 3 Oct.	85.6	21.3	29.2	50.5
24 - 27 Sept.	117.6	15.3	43.3	58.6
31 Aug. - 4 Sept.	100.5	8.1	25.5	33.6
20 - 23 Aug.	91.4	3.8	37.7	41.5
29 June - 2 July	63.5	3.7	19.3	23.0
24 June - 27 June	144.5	0.1	7.5	7.6

12. The feasibility report on the Nam Pong project in Thailand prepared by Rogers International Corporation, shows that the seasonal variation of flows in the Nam Pong is characteristic of all streams in Northeastern Thailand. In the late dry season, at the Pong Neeb damsite, where the catchment area is 11,980 km², the flow is scarcely measurable, while during the rainy season peak flows often reach 1,000 m³/sec for short period and a figure of 2,000 m³/sec is estimated as peak discharge of a typical large flood. The average annual discharge for the six complete years, 1955 through 1960, was about 1,780 million m³ varying from 1,309 million m³ in 1955 to 2,182 million m³ in 1959.

13. To estimate storm design hydrographs for use in the selection of a maximum flood hydrograph for spillway design and reservoir operation studies, both unit hydrograph techniques and multiple regression analysis were employed. However the results were not entirely satisfactory. It is reported that difficulties were encountered in estimating the true rainfall in such a large catchment basin when storm rainfalls vary considerably throughout the basin; the rainfall distribution is too irregular for satisfactory use in the unit hydrograph concept and the regression analyses are probably effected by lack of consistent concurrent data, insufficient number of precipitation stations representing the whole catchment and the inability to make consistent estimates of the influence of its various factors affecting the run-off. A flood hydrograph was finally adopted by direct comparison of storms causing the recorded peaks which were recorded in the period of daily records, namely 1921 onwards.

14. The province of Battambang is in the northwest of Cambodia. The first phase report on the development of Stung Sangker which runs through the province was recently prepared by SOGREAH. The following statement is made regarding the flow regime of the Stung Sangker. Ten rainfall stations have been in operation since 1960. They are, however, all located outside the catchment area with the exception of the Battambang station which has been in operation for a number of years, from 1928 to 1940 and 1950 up to date. Unfortunately, the values and regime of rainfall observed at these stations were found to have no relationship with the flows measured at Treng and Banan. It was reported it was not possible to connect the known precipitations (on the monthly scale as on the annual scale) with corresponding run-off volumes.

This is believed to be due to the fact that the upstream precipitation must be of a regime and a scale quite different from that observed from the existing climatological network. The catchment area at Treng is 2,142 km² and tentatively the maximum probable flood discharge is estimated as 2,500 m³/sec by analysing the high water stage records observed in the past using the rating curve prepared for this purpose.

15. The foregoing discussion is limited to only a few examples of the flow regime of rivers in this region. In every case, however, the figures on hydrological status differ so widely that it is quite difficult to estimate the real regime, such as maximum probable flood discharge, variation in annual run-off and flow discharge and so on. An assumption is that these variations are generally inherent in the nature of the monsoon itself. Of course, topographical conditions will have some influence on the pattern of rainfall; also the flow regime of a river can vary widely due to the location and area of its catchment basin. As a result, these hydrological data appear rather unstable which makes it difficult to promote more efficient use of water resources in this region.

III. To-day's demand on water resources in southeastern Asian countries and measures to meet this requirement

16. The explosive increase of population after the last war, especially in the countries of this region, is unprecedented in history and has now assumed a form which calls for immediate solution by many governments. At present, the annual rate of growth of the population in this region is estimated at around 3 per cent. It is reported, even in Thailand where today about 20 per cent of the total rice production is exported, the country will face a deficiency in food supply within ten years, if the present rate of growth of population of nearly 3 per cent per annum continues without a corresponding increase in rice production. According to our experiences, as far as agriculture is concerned, it is quite difficult to keep up with such a high rate of growth over a period of ten years even though the country is favoured by natural and socio-economic environment. Therefore, in countries where agriculture is predominant in the economy, continuous efforts should, of course, be made to increase agricultural productivity as well as its total product. Rapid promotion of industrialization is also assuming great importance and urgency.

17. The efforts to raise the living standard of the people of countries call for many projects related to the better use of water resources in various sectors of the economy. Many hydraulic structures, such as dams for reservoirs, intake structures for irrigation, power etc., canal systems for irrigation and navigation and dykes for flood prevention and so on, have been constructed or are under construction or planning in this region. As it is mentioned earlier, these projects have brought with them new problems, requiring urgent solution.

18. In recent years some irrigation tanks were built in the region to stabilize and to increase the yield of crops, but it was often reported that the existing pattern of cultivation had made it quite difficult for

the users to absorb the modernized irrigation system for productive use. Sometimes inadequate spillway capacity of dams specially in case of small scale development have caused flood damage due to structural failure. In certain cases, the demand for electricity cannot follow the production and this has resulted in the power stations, recently established, remaining idle. It should be recognized that modernized industry will require a certain scale and pattern of power supply. At the same time, the pattern of power production will also influence the pattern of the industry in a way to enable the industry to survive in a competitive market.

19. By what ways and means we can respond to the urgent demands on water for the benefit of the people in this region? At first, we have to know more about the hydrological status of the region. The flow of rivers in this region seem to be so unstable and appear rather different individually, due to topography and size of catchment areas. Yet it can be said that these factors will give a certain order of stability in the products of water itself, such as power produced and water supply for irrigation and domestic use. This leads us to the need of more accurate knowledge about the monsoon itself in order to plan more suitable ways for use of water in this region. To attain a clearer knowledge on this subject, more micro-studies will be necessary. As mentioned earlier, there has already been developed in the southeast Asian region a certain pattern of rice cultivation which is well adapted to its natural environment. It must be said that the peoples were quite successful in adapting themselves to their situation. To meet the present day requirement, it is necessary to reorganize the age-old pattern of living to suit the new condition. In this connection, in order to achieve immediate results from investment, the planning itself should be based on comprehensive knowledge of the present day pattern of cultivation and of the future structure of industry in the region. Probably an analysis of future demands for agricultural products will give some idea as to the diversificational type of agriculture which will govern the pattern of land use while an analysis of available resources will serve as a guide to the estimation of future structure of industry.

20. A river is like a long living thing. From its headwater to the sea, a river basin forms one dynamic and organic system. For example, if a dyke is constructed along the reach of a river, propagation of flood will be accelerated which may cause a rise in the height of flood wave and scoring of river bed in the upper reach and silting in the lower. The construction of dams in the headwater of a river basin will also change the pattern of flow in its lower reaches and this will cause not only some change in the flow regime of the river but will add new problems to the original pattern of water use in the river basin. Moreover it can be said that these phenomena are strongly influenced by the geographical characteristics of the basin which the rivers run through, which in turn contribute to the development of certain pattern of living by the people, well adapted to the natural environment. In conclusion, it must be emphasized that if nations wish to promote more effective development of their water resources, a more rational approach is needed to solve these requirements which are now becoming a serious element

in the course of economic development. The activities of Resources Council of Science and Technics Agency of Japanese Government in the field of resources development since it was established in 1947, will serve as an example. Ways of approach to solve these problems are given in the report "Resources Problems of Japan" presented to the Council in 1961. It emphasizes the need for analysis of facts to determine the real factors causing obstacles in the course of development of the country's natural resources and the need to search for solutions which will serve as a guide for further development.

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**UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS**

Agenda Item: A.1

Liberia

**SURVEYING AND MAPPING PRACTICES
FOR USE IN UNDER-DEVELOPED COUNTRIES**

**By J. Laurence F. SAWYER,
Chief, Liberian Cartographic Service,
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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

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SURVEYING AND MAPPING PRACTICES
FOR USE IN UNDER-DEVELOPED COUNTRIES

BY

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1. INTRODUCTION:

Most emerging nations are now undergoing a phase of rapid development. Older nations have seen the need to investigate possibilities of further economic expansion. In places with scarcity of natural resources emphasis is being placed on refinery processes and chemical industries. In many parts of Africa, however, the natural resources available would for a long time provide most of the needs and reserves for the inhabitants.

1 (a) Whether or not the exploitation of natural resources and urban development would take the proper pace depends upon the type of maps and cartographic services available. Investigation and exploration costs can be so high, and the task so long and tedious, that investors may often shrink from a lucrative venture, and the countries' economy be thereby retarded. Yet with adequate maps and modern cartographic facilities every information can be brought to the investor in so short a time and at a cost so low as to encourage investments that otherwise might have been postponed for several decades. Investigation made in the United States of America have shown that having topographic material available can reduce planning costs by seventy (70%) percent. The records give us a number of clear examples and reports underlying these experiences. For example, an industrial area in the State of North Carolina lost ten million (\$10,000,000) dollars because new industries preferred to settle elsewhere owing to the lack of maps with contour lines. According to another American source, the importance of maps was clearly demonstrated in planning a highway sixteen (16) miles long. Five thousand (\$5,000) dollars were spent on three local surveys and then the costs were estimated in the usual manner. Before starting the construction work, a topographic map was produced at the price of two thousand two hundred (\$2,200) dollars. By use of this map a new road-bed was chosen, and as a result, the construction costs for the highway diminished by two hundred thousand (\$200,000) dollars as compared with the original estimate. In another case a railroad company economized eighty-five thousand (\$85,000) dollars, by changing the planned road-bed of a railroad track after studying a topographic map. These figures are supplied by the Cooperative Society for Geodesy and Cartography, Frankfurt, Main, Germany.

1 (a) (i) Indeed the economists, city planners, geologists, highway engineers, architects, agriculturists, sanitary engineers and all design engineers regard topographic maps as a priority for economic development in the quickest and most economical way.

1 (a) (ii) Geodesy and Cartography, therefore must be made with modern high speed and high precision instruments and methods in order to meet the press-

ing needs of the fast growing economies of developing areas.

2. ORGANIZATION:

First and foremost it is advisable that each country establish a National Cartographic Service along organizational lines that would ensure maximum efficiency. There should be three sections of this Service, namely: Planning, data collection and examination, production and actualization; (b) Reproduction and dissemination (c) Correlation and application.

2 (a) Planning, data collection and examination, production and actualization would entail collection and grading of existing data and securing further information by application of techniques in Geodesy, Aerial Photography, Photogrammetry, Hydrography, Cartography and field checking and adapting the information to the requirements of all phases of economic development that might make use of information which could be pictorialised on maps. Among these we might include geological, soil, and forest exploration and exploitation, as well as planning and lay-out of projects for human welfare, cadastre and remembrement.

2 (a) (i) Much of the work done in this phase must be performed in air conditioned chambers and the equipment preserved in low-temperature and low humidity storage compartments. Ample travelling facilities should be provided for field crew and sufficient space for office personnel. The administrative section of this Service must be of equal efficiency as the purely technical section, so as to be of assistance in evaluating time-and-motion studies to enable production to meet the dead-line.

2 (b) Reproduction sections are always necessary adjuncts to the Cartographic Service. Preparation of photostats, enlargements, blue prints and offset prints are expected to be done in this section. For large quantities of duplications or for large-sized prints, however, it might be advisable to work in coordination with the Government printing services or with commercial printing firms.

2 (b) (i) Dissemination of information could be effected through coordination with the users directly or through sales agencies and advertising in engineering journals.

2 (c) Correlation and coordination between the activities and facilities provided by the Geodetic and Cartographic Service should be made with all organizations likely to use these facilities or to contribute pertinent data in Geodesy and Cartography. These related organizations would include the Real Estate or Cadastral Office through land registry; the Bureau of Soils, Irrigation and Reclamation; The Forestry Service; the Geological Service; the Armed Forces Mapping Service; the schools, through atlases; the Municipal Construction Services; the rural resettlement agencies; the economic planning agencies and all others so related.

2 (c) (i) One branch of the National Cartographic Service would have to be devoted to demonstration of the best possible application of maps in each type of economic development.

3. METHODS:

It is always necessary that surveys and mapping precede the economic development program. It is quite obvious, however, that in the new and emerging nations, with no mapping done already and whose rate of development is very rapid, the old classical methods of surveying and mapping are too tedious to complete the over-all mapping in time to precede or even be abreast of the economic planning program. Extensive use will therefore have to be made of Photogrammetry and of the latest electronic measuring and computing techniques. A centralised mapping office is also recommended so as to minimise the waste

due to a multiplicity of mapping services in various agencies.

3 (a) Quite a large variety of instruments and methods are currently available. These are displayed en-masse at related international scientific conferences, notably the Congresses of Photogrammetry, Geodesy and Cartography and of the Federation International des Geometres.

3 (a) (i) While modern instruments are quicker and easier to operate, they should, however, be adapted to the nature of the task on hand. As much of the territory of developing countries is still unmapped, these countries need not hesitate to check into a vast storage of disconnected first order work already available, as would have to be done in already developed countries. A complete over-all mapping scheme would often prove more economical.

3 (b) This procedure would entail establishment of horizontal and vertical control, electronically controlled vertical aerial photography, and then photogrammetry, photo-interpretation and cartography.

3 (b) (i) In the case of hydrographic charts, these would require electronic soundings, applied to map with shore-line details. Geological, soils, vegetation and other special purpose maps would require additional ground investigation.

3 (c) One scheme for a small-scale topographic mapping of a large territory would entail locating the geographical positions of points at wide intervals by tellurometer or Mann's zenith-camera observations, applying gravimetric compensation. Vertical control could be had by running automatic levels along selected roads and connecting them with micro-barograph readings and by interpolating spot levels run to river surfaces at wide intervals. For aerial triangulation, infra-red vertical aerial photography should be taken at scale 1:70,000 with a fully automatic extra wide angle camera synchronised with Shoran or such other electronic measurements to ground control points, and with a horizon camera, an airborne profile recorder and its accessories, and with airborne geophysical prospecting equipment. Photograph coordinate points obtained by aerial triangulation could be adjusted by Yerie block adjustment methods. For very small-scale mapping stereo templates could suffice. Controlled, annotated mosaics could be made from rectified photographs.

3 (c) (i) For very large-scale mapping, which would be required for lay-out and construction projects, more precise methods would have to be employed. This would necessitate control provided by aid of precise leveling and horizontal measurement. It would require aerial photography at scale 1:25,000 followed by an accurate aerial triangulation and plotting. There is a wide range of precise instruments on the market. It is recommended that selection of the very best be made for very large scale mapping. Many instruments and methods described for use in small-scale mapping can be adapted to large-scale mapping. The high speed and accuracy with which survey and mapping can be done by use of photogrammetry with electronics makes its use indispensable. Moreover, the cost required to complete extensive projects is negligible when compared with the old classical methods.

3 (c) (ii) Contours could be drawn on maps at intervals depending on the scale required and the accuracy of the vertical aerial photography and the vertical and horizontal control. Determination of contour lines could be done either on a projection-type anaglyph or mechanical plotter or on an ordinary stereometer-mirror-stereoscope depending on the scale and contour interval required

3 (d) The several plotted sheets would have to be coordinated and projected on some central projection system: probably the Universal Transverse Mercator for small scale mapping or the Hotine's rectified skew polyconic or such other type of orthomorphic projection for large scale mapping.

3 (e) Reproduction and application phases would have to be executed with

equal efficiency.

3 (f) The need for highly trained personnel cannot be over-emphasied. Already trained personnel need specialised or refresher courses. They also need to attend related international scientific conferences and seminars in order to keep up-to-date in their techniques and instruments.

4. INSTRUMENTS:

4 (a) Geodesy: The development of the tellurometer and the geodimeter has introduced great economy in the process of triangulation and traversing and the use of these should be introduced wherever they can substitute old methods. Use of modern theodolites with glass circles would still be necessary; as would leveling instruments with compensators. Improved tachymeters as well as subtense bars, micro-barographs and improved range finders would find use in filling large gaps in the mapped area, and in actualising old maps in rapidly improving zones.

4 (a) (i) Portable gravimeters, which are too costly, would have to be rented. This condition holds also for zenith cameras, astrolabes or Gigas type theodolites with accessories for primary determination of geographical positions.

4 (b) Photogrammetry: Twin-engined aircrafts with tail-wheel landing gears are often preferred. Fully automatic aerial survey cameras, horizon cameras, as well as airborne electronic distance measuring equipment both for vertical and horizontal positioning should find increasing use. Airborne scintillometers and magnetometers should form a part of the equipment on the aerial photographic mission.

4 (b) (i) Photo-laboratories would have to be equipped with automatic rectifiers and dodging printers in addition to the standard laboratory equipment. Computing and plotting rooms would have to be equipped with electronic computers and precision projection and mechanical type triangulators and plotters. Material made of stable base would have to be provided for drawing and scribing.

4 (b) (ii) Stick-up symbols and lettering would have to be applied to the actualised map. Several projections would have to be made by rectifiers or reductions by pantographs or optical means before the finished map is sent onward for off-set printing, distribution and application.

5. AN EXAMPLE:

We in Liberia have made extensive research into our current needs in this respect. A Liberian Cartographic Service was founded in 1951, in which the United States of America played a predominant role under the U.S. "Point Four" program. The United States participation in this Service was concluded early in 1956 after four and a half years of direction involving ten (10) U.S. Coast and Geodetic Survey technicians serving in two separate groups; and visits of the top ranking staff officers of the U.S.C. & G.S. The ten-year progress report of the Liberian Cartographic Service would give a detailed account of the operation of this service. The report covers training abroad and locally of photogrammetrists, geodesists, aerial photographers, photolithographic pressmen, an aircraft pilot, laboratory technicians and hydrographers. It also covers work performed: near - first-order determination of astronomic position with Mana zenith camera, aerial photography at scales 1:40,000 on contractual basis and at larger scales by the service's own personnel and equipment. It covers establishment of vertical and horizontal control and of preparation, printing and distribution of planimetric, topographic and hydrographic maps. A more detailed account of methods used in Liberia is given in the National report on instruments and methods by J.L.F. Sawyer, to the Ninth Congress of the Federation International des Geometres. An investigation was made later by the United Nations sponsored International Training Center for

Aerial Surveys under the personal direction of Professor Dr. Ir. W. Schermerhorn of world renown. His report is available in bound volumes at the I.T.C. An excerpt from this is attached to the ten-year progress report of the L.C.S. showing the personnel, instruments and office facilities needed together with their costs. The Schermerhorn analysis lists equipment, supplies and personal for a three-year period at a cost of four hundred and sixty eight thousand (\$468,000) dollars of which one hundred and eighty five thousand (\$185,000) dollars is for an air-conditioned building and eighty thousand (\$80,000) dollars is for a twin-engined aircraft.

5 (a) Within the last quarter, Albert Nowicki headed a team of U.S.A.I.D. technicians which made a further analysis of possibilities of resuscitation and improvement of this Service, which is so vital to the economic development of the country. The Nowicki report recommends a unified or centralised mapping Bureau which would embrace every type of mapping required for the country. In his detailed organization charts he outlines personnel distribution, grading and production flow for an outfit of 347 persons responsible for survey or data collection and mapping. The personnel are as follows: meteorological surveys - 21, hydrological surveys-10, geological surveys-30, mining surveys-14, forestry surveys-26, soils surveys-28, general mapping (in which he includes field surveys photogrammetry, manuscript engravings and reproduction)-125, records division-11, planning division-5, logistics division-48, library services-6, personnel office-9, archives-2, finance-9, and headquarters-3. As the existing situation in Liberia does not combine soils and forestry surveys in the same Department with the other branches, the Nowicki analysis provides for liaison facilities in case the unification cannot be achieved. He outlines a procedure whereby all useful information would be pictorialised on maps at the scales ranging between 1:250,000 and 1:50,000. This program recommends a building with the space of 53,000 square feet costing \$600,000 distributed as follows: meteorology-3,000 square feet, forestry-4,000 sq. ft., water resources-2,000 sq. ft., mines-2,000 sq. ft. geology-4,400 sq. ft., mapping-21,020 sq. ft. staff and service-8160 sq. ft., Department staff-2640 sq.ft., Department headquarters-80 sq. ft., soils-3360 sq. ft. miscellaneous (stairways, etc.,)-2340 sq. ft. He recommends equipment costing \$475,000 and an operations budget of \$625,000. Following these pre-requisites Mr. Nowicki and his team expect a properly functioning and balanced Mapping Department capable of supplying printed large scale topographic maps of the whole country and having functional elements responsible for collecting, analysing and translating into mappable and statistical form the requirements for the economic development of the country, which would include geological, water resources, economic minerals and meteorological surveys studies and tests; and cadastral and boundary surveys, mapping and title registration.

5 (b) The Liberian Surveyors Mutual Association, now nearly eight years old, is coordinating the activities of surveyors associated with it and raising the professional standard of survey engineers in general, in terms of efficiency, integrity, salary and emoluments. The standards required by this association are comparable to universal standards and the salaries range between two hundred and fifty and eight hundred dollars for professional surveyors. Educational facilities for young surveyors are being provided by the University of Liberia, the Armed Forces Intelligence, the Bureau of Forest Conservation, the Highway Survey and Municipal Survey Sections of the Department of Public Works & Utilities, the Meteorological Service, D.P.W.U., the Geological Service and the Liberian Cartographic Service of the Bureau of Natural Resources and Surveys, and the survey offices of several private firms operating in Liberia.

5 (c) In this program as outlined, foreign nationals play a vital role and most of the instruments are of the best foreign manufacture that our revenues can afford. Thus the emphasis has been placed on accuracy and results; which

of course, leaves the door wide open for whole hearted participation by technicians and businesses of all nationalities in the development of the cosmopolitan Republic of Liberia.

5 (d) While the above example indicates present performance and projected studies for Liberia it would serve as an index for the requirements of other developing Countries.

6. CONCLUSION:

We need not over-emphasize that it is our hope that the current program envisaged by the United Nations, with ourselves as participants, would provide an avenue for bringing Cartographic Services up-to-date. This, of course, would require a vigorous cooperation of all parties concerned. It is advisable for the United Nations Technical Assistance section to undertake pilot projects of limited duration, set up regional advisory offices and expand the program at the International Training Center for Aerial Survey, Delft, Holland.

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Paragraph 5:

"Ten-year achievement of the Liberian Cartographic Service"
Author: J. Laurence F. Sawyer. Copies available at the Liberian Bureau of Natural Resources & Surveys. Copies also in the minutes of the Tenth Congress of the Federation International des Geometres.

Paragraph 5:

"Reorganization of the Liberian Cartographic Service"
Author: Prof. D. Ir. W. Schermerhorn. Copies available at the International Training Center for Aerial Survey and at the Bureau of Natural Resources and Surveys of Liberia. A pertinent excerpt is attached to the "Ten-year achievement of the Liberian Cartographic Service."



**UNITED NATIONS CONFERENCE
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**LOCAL SOURCES OF ENERGY, MICRO-HYDROELECTRIC STATIONS,
WITH PARTICULAR EMPHASIS ON THE ELECTRIFICATION
OF AGRICULTURE**

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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

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Local Sources of Energy, Micro-hydroelectric
Stations, with particular Emphasis on the
Electrification of Agriculture

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Determination of demands

/1/ Apart from larger industry centres formed in certain areas, the demand for electric energy of underdeveloped countries is, as a rule, characterized by a low density. Thus, when comparing the different areas, the demands expressed in kW/km^2 or kWh/km^2 values cannot be averaged for the territory of the whole country, as this would result in misleading data; only those areas should be taken into consideration which are inhabited, which are cultivated or suitable for cultivation.

/2/ From the view point of electric energy demand, less developed countries are characterized primarily by a monocultural agriculture. This determines the living standard in the first place, depending on the degree of productivity and on the world market price of the products. Agricultural structure may be on a low level if production methods remain on their original scale and the produce is marketed in its original form. Further, there are possibilities of a low-degree processing as e.g. cleaning, husking, drying, etc. Finally, there may be a certain degree of industrial processing, as milling, storing, etc. of the produce. In the latter case auxiliary plans have to be considered. Demand for electric energy may be increased to a great extent by irrigation and pumping of various kinds necessary for production whereas, for the time being, other types of soil cultivation may be generally disregarded in this respect.

/3/ A higher-degree agricultural cultivation results in the raise of the living standard of the population; thus, agricultural production demands increase parallel to household demands, although these may grow even much faster. Very scarce statistical data are available for the estimation and evaluation of the demands of less developed countries which are at the very beginning of their electrification.

/4/ However, by reverting to an earlier stage of the development of European countries, for which statistical data are available, we may gain some information on the interdependence between agricultural development and electric power demand.

/5/ In certain countries, formerly of a predominantly agricultural character, - for which Central- and East-European countries are good examples - the rural electric energy demand did not exceed 1 - 16 kWh/ha of arable land; during the 40-year period between 1920 and 1960 this value increased about 20-fold and now amounts to

20-30 kWh/ha. In the same area, the consumption of the rural population amounted to yearly 10-15 kWh per household; this value equally increased 20-fold, i.e. reached the annual value of 250-300 kWh per household. The low value of 10-15 kWh including the not-electrified households is obtained by dividing the total consumption of the area under consideration by the total number of households. The increment of actual consumption of electrified households is, therefore, much smaller, only 2-3-fold since it amounted, at the date of connexion, to 60-70 kWh/year.

/6/ It goes without saying, that experience gained in European rural electrification cannot, forthwith, be taken as an example. In the first period of the 40-year development, demands increased, to a certain extent, simultaneously with application possibilities, because there were less consumption possibilities available than now. Furthermore, electric machinery /motors, transformers, switch-gears, appliances/ represented exceedingly high costs as compared to the market prices of agricultural produce. Practically, besides lighting, there were no household appliances available.

/7/ Electrification started today is realized under quite different circumstances and the easy acquisition of simpler appliances results in a rapid increase of consumption. Whereas in 1920 a rural household required merely lighting which, considering the simplicity of rural life, did not exceed 60-70 kWh per year, nowadays the initial consumption attains 150-200 kWh, as household appliances are available in large quantities and at low cost. With the investments for agricultural production the agricultural situation becomes similar. Whereas in 1920 an agricultural unit /farm/ consumed 1-1.5 kWh/ha, nowadays an area of a similar character starts by an annual consumption of 10-15 kWh as soon as the network is able to supply electric power in a sufficient quantity. This is mainly due to the fact that electrically-driven agricultural machinery is available at a considerably lower price as compared to that of the produce than forty years ago.

/8/ However, experience gained in European countries must be cautiously applied to the conditions prevailing in recently liberated territories because the population of these is less aware of the possibilities of utilizing electric power than the population of the European ones. The many millions of rural population are unable to appreciate the economic advantages due to the mechanization of production. But even if they were able to do so, the capital and the professional training necessary for rational use are not available. Therefore when planning the electrification of less developed regions, we must rely on existing intensive economic units /farms/ under proper guidance or on producing and marketing organizations, co-operatives or similar associations recently established. Rural electrification installed can be expected to meet the requirements of lucrativeness, only if such major units are connected to the grid. In case of scattered settlements the installation of minor individual power stations will be indicated for a long time to come. As the networks to be constructed will seldom extend beyond the limits of the settlements, the construction of high or medium-voltage networks may be envisaged only in exceptional cases, i.e. in regions where, owing to favourable natural conditions, the density of the population is greater, where the generation and the distribution of more MW at 15-45 kV medium-voltage will be possible. We do not consider

regions where large energy sources /water or coal/ are available and may facilitate larger industry concentrations. In other regions chiefly household demands, a small-scale agricultural processing and some small-craft consumption may be reckoned with.

/9/ Whatever turn conditions of electrification may assume, some basic considerations must be observed. These are:

/a/ The simplest execution possible of the whole plant, ensuring relatively low investment costs, easy handling, and simple maintenance. The possibility of a simple construction resulting in low efficiency is unimportant if it can be compensated by lower investment costs. With the application possibilities envisaged at an initial stage of electrification /households, small-craft, processing of produce, etc./ the role of a lower efficiency is negligible as compared to the utility and the value of the results attainable.

/b/ Local sources of energy should be utilized to the greatest possible extent.

/10/ Some technical characteristics and economic aspects are given for local power plants corresponding to the above conditions:

Automatically operated micro-hydroelectric stations

/11/ An interesting solution is the GANZ mignon-turbine, a type working well at the initial stage of rural electrification of Hungary, in which the turbine forms a complete unit with the generator and the automatic regulator is, therefore, transportable and ready for installation. Its main advantage is that it does not require permanent handling and supervision. This is necessary only when starting and switching off and during the periodical lubrication of the bearings. The turbine is constructed with a regulator of an exceedingly simple design, with which the number of revolutions can be kept almost constant at any load; this is an important condition for high-quality electric power generation. Thus the water afflux is regulated by the actual power demand. The gross head is of the order of 5-20 m, the water quantities about 220-600 l/sec, and the output 8-80 kW. For the turbines generators are applied with an output of 20-30-45-60-90 kVA. The turbines are of the propeller-turbine type with a vertical shaft and with permanently adjustable fixed and rotating blades. The water inlet is through a cast-iron spiral box. In this box there is a manually driven shutting valve. The water quantity flowing through the turbine is regulated by a bell-shaped lock placed at the base of the leading wheel. Essentially, the turbine regulation is a pendulum provided with a weight working against scroll effect, bringing the bell-shaped lock, in case of revolution variations, into a different balance position, thus adjusting the water absorption capacity of the turbine to the actual output demand. The diagram of the whole design is presented in fig. 1 demonstrating the extraordinary simplicity of the whole construction. The turbine house can be constructed of brick or of timber, but an outdoor execution is equally feasible as shown in fig. 2. Beside this, very little under-water construction work is required. The end of the headwater channel is a simple concrete lock wall comprising merely a trash rack and a suitable small sluice, where, beside the small walling around the turbine, the tailwater channel does not need any further installations.

/12/ Another solution of micro-hydroelectric plants is the free radial turbine, the BANKY-turbine, with a simple double-flow, a type ranging between the FRANCIS and the PELTON turbines, but of a much simpler and cheaper make than any of these. In this type the water jet hits the running wheel twice, once tangentially, then leaves it radially, passing through the inner space of the running wheel. The arrangement of the water inlet stub is such that the water jet always reaches the running wheel at an identical angle. The diameter of the running wheel is independent of the amount of water and only its width may vary. In case of larger water amounts two running wheels can be mounted on one shaft. As in the case of all free radial turbines, the running wheel should be placed directly below the tailwater surface and the tailwater level should be kept at a constant height. This turbine is suitable for the utilization of very low heads, viz. in one series at a range between 1.5 and 10 m and in another series at a head between 2 and 60 m. The diagram of the turbine is given in fig. 3, showing that the construction can be adapted to the most simple conditions. Hydraulic structures are of the smallest extent.

/13/ Turbine revolutions are very few therefore coupling with the generator is not always possible and a generator drive with a V-belt might be a more economic solution. Similarly to the above mentioned mignon-turbines, regulations may equally be realized by an automatic and centrifugal system. Both kinds of turbines are constructed expressly for conditions, where independent units can be supplied without network co-operation and it is possible that even with extreme load variations revolution variations will not exceed $\pm 5\%$.

Small-size diesel aggregates

/14/ These are suitable where no sufficient amounts of hydro-power sources are available. Their output, as referred to motor capacity, varies between 20 and 500 HP, with direct shaft connexion and a three-phase synchronous generator of a corresponding capacity. The number of revolutions of the most popular types is 1000. The erection of these machines in tropical regions is possible even under most adverse conditions, only the problem of the cooling water has to be solved. Under normal conditions cooling is effected in forced circulation; in very hot regions cooling can be effected by forced ventilation, where ventilation capacity may attain even 10-12% of the motor capacity. As regards cooling, it may be mentioned that for 20-25 HP machine units 15-20,000, for 80-100 HP motors 60-70,000 and for 200 HP motors 130-140,000 kcal/h heat reduction should be taken into account.

/15/ Fuel consumption varies between 260-300 g/kwh, according to machine capacity. In forced operation cooling-water supply is about 5%. If the water is too hard a heat exchanger has to be applied, with easy-cleaning pipes, thus motor cooling can be effected by a single filling with distilled water, for the cooling of which fresh water may be used. At small outputs up to 25 HP the starting of the motor can be done manually, above this value, by compressed air. The filling of the air reservoir is effected by a compressor-driven 4-5 HP motor. The capacity of the starting tank ranges between 60 and 100 litres, with a pressure of 35 atm.

/16/ Apart from the substructure, the erection of this machine unit practically does not require any building work, but /where there is no danger of frost/ it may be erected in simple, prefabricated open-side sheds. This is the more expedient as in this case there is no need to provide for a special ventilation of the power house. Up to 500 HP the voltage applied is 400/231 V low-voltage. The switch-gear of the machine unit is equally a mass-produced, preferably encased installation provided with the simplest instruments as voltage- and ampere-meters, a period indicator, cooling-degree- and oil-temperature indicators, a generator and generator instruments.

/17/ Thus, for the equipment of the complete power plant the following essential elements are needed:

- /a/ aggregate /diesel engine and electric generator/;
- /b/ starting gear with auxiliary motor;
- /c/ small-size cooling pump /if there is no cooling water available/;
- /d/ tank for crude oil, capacity sufficient for about one month;
- /e/ tank for crude oil, holding fuel for 1-2 days;
- /f/ encased electric switchgear;
- /g/ a simple roof construction.

/18/ For operation, the following work is needed:

- /a/ daily starting up and lubrication;
- /b/ weekly cleaning of filters for crude and lubrication oil;
- /c/ Monthly cleaning of air filters, cleaning of boosting nozzle and, as circumstances may require, cleaning of level- and pressure valves of oil pump;
- /d/ 3-monthly cleaning of cooling equipment, periodical removal of scaling;
- /e/ once a year the motor has to be dismantled and subjected to careful maintenance, however, this is not the task of the local operator, but that of the service.

/19/ From the operations enumerated it is obvious that the technical requirement for the operation of such a plant does not exceed that of a truck driver.

Biogas plants

/20/ In agricultural, ie. cultivated areas the use of such power plants is often suggested since sufficient quantities of refuse from plant growing and stock-breeding are available for gasification.

/21/ With a proper processing of such refuse gas of high value can be produced, containing about 65% methane /CH₄/ and 35% carbon dioxide /CO₂/.

/22/ For the production of biogas numerous experiments have been carried out, among which especially the Schmiedt-Eggersgluss and the Masseaux processes have attained widespread application. Large amounts of agricultural waste have been examined in order to determine which to use, with the proper addition of dry substance, for obtaining a good gas mixture. As the most suitable ones chaff, corn-stalk, beet-leaf, flax straw, cereal straw, and manure should be mentioned. From these substances about 250-400 litres of gas/kg of dry substance can be gained, with an average methane content of 60%.

The essential elements of this installation are two or three cylinder-shaped concrete tanks of 8-15 m³ capacity, filled with prefermented rotting substance, left there for about 2-3 months. The mixing in of agents greatly promotes the fomenting of gases. By the use of several, alternately fed tanks a continuous gas extraction can be ensured. The gas is collected in tanks, from which - especially in tropics and in less developed countries - it can be used, by means of a gas engine, for the generation of electric power and/or, if need be, for the production of industrial steam. The substance remaining after gas extraction becomes nitrogen-enriched and can be used in intensive farming for soil improvement. The caloric value of the gas gained generally ranges between 5300 and 5500 kcal/m³.

/23/ A very favourable method of gas utilization can be ensured by compressing the gas. As is well-known, gas production is continuous, whereas its use as electric power is subject to great variations. Gas is, therefore, compressed in 1-2 gas containers of 50 l capacity, at 100 atm. Thus 7-14 m³ biogas can be stored. Assuming the efficiency of the gas engines used at 25%, approximately 1.3 kWh can be gained from 1 m³ biogas. Although biogas can, according to the above, primarily be utilized as fuel for generating electric energy, in tropical regions it can find an appropriate use for absorption refrigeration. At an ambient temperature of 40° C the consumption of a 200 litre refrigerator amounts to about 2 m³ per day.

/24/ Investment costs may be assessed as follows:

for building	20 \$/m ³
for engineering	5 \$/m ³
electric installations, tubing, design, preparatory work	15 \$/m ³
totalling	40 \$/m ³

/25/ In Hungary, there are several biogas plants of this kind in operation. Their spreading has been restrained merely because, by now, the electric power network is available everywhere. However, since gas production yields valuable substances for soil amelioration, it is deemed necessary to increase the number of biogas plants at suitable sites.

/26/ Considering that no uniform standard processes are available and that no experiments have so far been undertaken to investigate the rotting flora of the different tropical regions, especially marshlands for biogas production purposes, the establishment of minor experimental plants in the regions concerned is highly advisable.

Wind power plants

/27/ Since we have no time to dwell on solutions of construction and on results attained, only some economic considerations can be advanced. As a rule, utilized wind power irregularly fluctuates between zero and maximum values and only a certain part of a given wind power strip can be utilized. For small wind power plants a 10-12 m/sec minimum wind velocity can be taken as a base. Beyond these values, dimensions may become necessary whose profitability might be dubious. Similarly, wind velocities below 2-3 m/sec deserve no consideration whatsoever.

/28/ According to experience acquired so far, a satisfactory economical use could be ensured if a 5-10 m/sec wind velocity were available at least for 1500 hours a year, however, it should be borne in mind that the periods of wind velocity and those of power demand do not coincide and, therefore, wind energy can be regarded merely as an auxiliary source. It can be utilized as an independent energy source, only if suitable accumulator storage can be provided for. However, in this case the complexity of installations and the high demands of operational training reduce practicability. In accordance with the above, exceptions can be made only on sites, mostly sea-shores, where a constant value of wind velocities during longer periods can be reckoned with.

Steam engines

/29/ One of the power engines most suitable for the purpose is the semi-stationary steam engine with a small output of 50-60 HP. These engines are manufactured in series. The average steam pressure in the boiler is 14 atm., the steam temperature in front of the engine is 320-330° C, revolutions are 280/min. The piston steam engine drives the synchronous generator of 40 kW capacity with a fly-wheel belting.

/30/ The boiler construction is suitable for coal and for firing with various kinds of fuel, e.g. hard coal, brown coal, peat, turf, timber waste, straw, rice- and cocoa husk, etc. For the burning of fuels of a low calorific value the boiler is provided with a suitable staggered grate. To ensure proper thermal efficiency, superheaters are installed.

/31/ The compound-system steam engine is provided with low- and high-pressure cylinders, condensers, excenter circular piston drives, a centrifugal regulator, and a manually operated revolution control device.

/32/ If fresh water is unavailable in sufficient quantities, instead of a condenser an exhaust may be applied. The water supply of this installation may be fresh water without any softening. For this purpose the pipes are installed to allow easy dismounting and cleaning.

/33/ Fuel consumption is about 4500 kcal/HP-h, steam consumption about 5.8 kg/net hour.

/34/ This plant is suitable for rough operation as it requires simple handling and can be erected outdoors; only a protective roof has to be constructed. For firing agricultural waste, predrying is advisable, which can be done on the sun. The electric installation connected to this engine is identical with that mentioned for diesel plants.

/35/ In each case the possibilities of application of the various types of power plants have to be weighed in accordance with local conditions. Should the provision with energy sources involve difficulties, it becomes evident that primarily the erection of a hydro-electric plant and secondarily the construction of a small steam power plant burning waste fuel have to be taken into consideration. Referred to a 50 kW unit, costs may be assessed as follows:

/a/ Hydroelectric power plant: 8-10,000 \$, including a simple mignon-turbine up to 6-10 m head, where no coastal protection work is involved and only a barrage and a sluice have to be built.

/b/ Thermal power plant: 6,000 \$, can fire waste fuel too;

/c/ Diesel plant: about 7,000 \$;

/d/ Biogas plant, about 10-12,000 \$, for the daily production of 250 m³ steam;

/e/ Wind power station: about 8,000 \$.

/36/ These are only the costs of machinery, most probably to be ensured by imports, whereas costs of construction and excavation work, concreting, civil engineering are not included in the above estimates as they may vary considerably according to local conditions and, therefore, may be assessed differently.

/37/ As for operation costs, only the fuel of diesel engines may represent high costs, whereas for the other power plants the energy source is available at the site /water, waste, fuel/ and, as a matter of fact, estimates for these are not possible. When choosing the type of the power plant, apart from the energy source, operation and maintenance possibilities should also be taken into consideration. In this respect, the most suitable solution is the micro-hydroelectric station, the second in rank is the biogas plant, being similarly simple, but possibilities of its installation greatly depend, as mentioned above, on the quality and the availability of waste. In the third place comes the wind power plant, equally requiring a permanent operating staff. As for professional training, the two latter installations require, despite their relative simplicity, a well-trained staff. Here it should be mentioned that, owing to the widespread use of diesel vehicles, properly trained technicians are easily found. As for spare parts, the sequence is about the same. However, it should be pointed out that the steam engine is extremely enduring and its requirement of spare parts extraordinarily low.

/38/ With all the power plants enumerated, generally a very low number of utilization hours has to be taken into account, in many cases not exceeding 1500-2000 hours annually. Therefore, the kWh produced is charged with rather high standing costs. Taking 10,000 \$ as the average cost for the erection of a 50 kW power plant and putting maintenance costs, including capital investment, at 10-15%, one kWh generated is charged with a standing cost of 2-2.5 cents; in case of a diesel engine or a steam engine, fuel costs have to be added in accordance with prevailing local conditions.

/39/ When selecting the type of power plant one has to bear in mind that with the increase of demand the capacity assumed will not be sufficient. In the future, power will be supplied from large-size distant power stations and the small power plants will become unnecessary. In these cases they have to be shifted over to sites where they might again become profitable. This applies to any small power plant, except to hydroelectric stations which, as matter of fact, are fixed to a site but, later on, they can be economically connected to the established network. Therefore, although 50-100 kW plants have been considered here, too, the water power available has to be utilized to its maximum capacity and, if not the whole

machinery, so at least the hydrological building constructions should be designed accordingly. However, a later extension of the latter generally encounters various difficulties.

Electric distribution equipment

/40/ The capacity of local power plants is designed for 20-100 kW, although in the case of hydroelectric plants and diesel plants this may be raised up to 200-500 kW. Plants above this capacity are beyond the scope of the present study and they are erected according to quite different considerations.

/41/ The yearly electric energy consumption per capita of developing countries may be assessed at 20-150 kWh. Assuming 1500-2000 utilization hours, a 50 kW capacity power plant is able to supply 70-90,000 kWh energy per year, which may be sufficient for the supply of a population of 800-1500. In this the household demand and the consumption for agricultural production are included which, generally, do not coincide in time.

/42/ As already mentioned, for these outputs and for the dimensions of the regions to be supplied, a low-voltage distribution will be sufficient, which, originating from the power house, may extend to 2-3 km. The line can be constructed in a simple manner with plain wooden poles which, to prevent them from rotting in the soil, should be placed on concrete socles which can be manufactured with the concreting necessary at the time of erection of the power plant. These installations should be manufactured with three-phase and zero conductors, with an earthed neutral and fuses placed at branching points.

/43/ Here the question arises what the optimum voltage should be. It should be uniform, considering that the standard voltage of 400/231 V might seem too high as part of the population is unaware of the contact danger. Some authors propose the application of the lowest 3 x 231 V system. However, this is by no means motivated as the risk is hardly any smaller than in the case of the 400 V voltage. Anyway, great care has to be taken for an effective contact protection. Although they are evidently costlier it is recommendable to apply metal or synthetic encased fittings, resisting mechanical stress as well. In this respect, so far, there is no uniform standpoint, however, requirements of shock-proof fittings should be borne in mind to the highest degree.

/44/ Should the electric power plant, owing to a favourable presence of energy sources, be constructed at a larger capacity than the 50-100 HP mentioned, e.g. in case of a diesel or hydroelectric plant up to 500 kW, it is recommended to transform up the generator voltage and to introduce a uniform voltage here too. 11 kV or 16 kV can be recommended since this voltage still allows to provide greater distances by a single-phase insulating material for poles and with cast-insulated transformers which are mass-produced. Later on higher voltage networks of this kind may easily be connected to high-voltage systems of more distant power stations or networks.

Conclusions

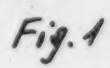
/45/ The characteristics of the electrification of rural areas in less developed countries are:

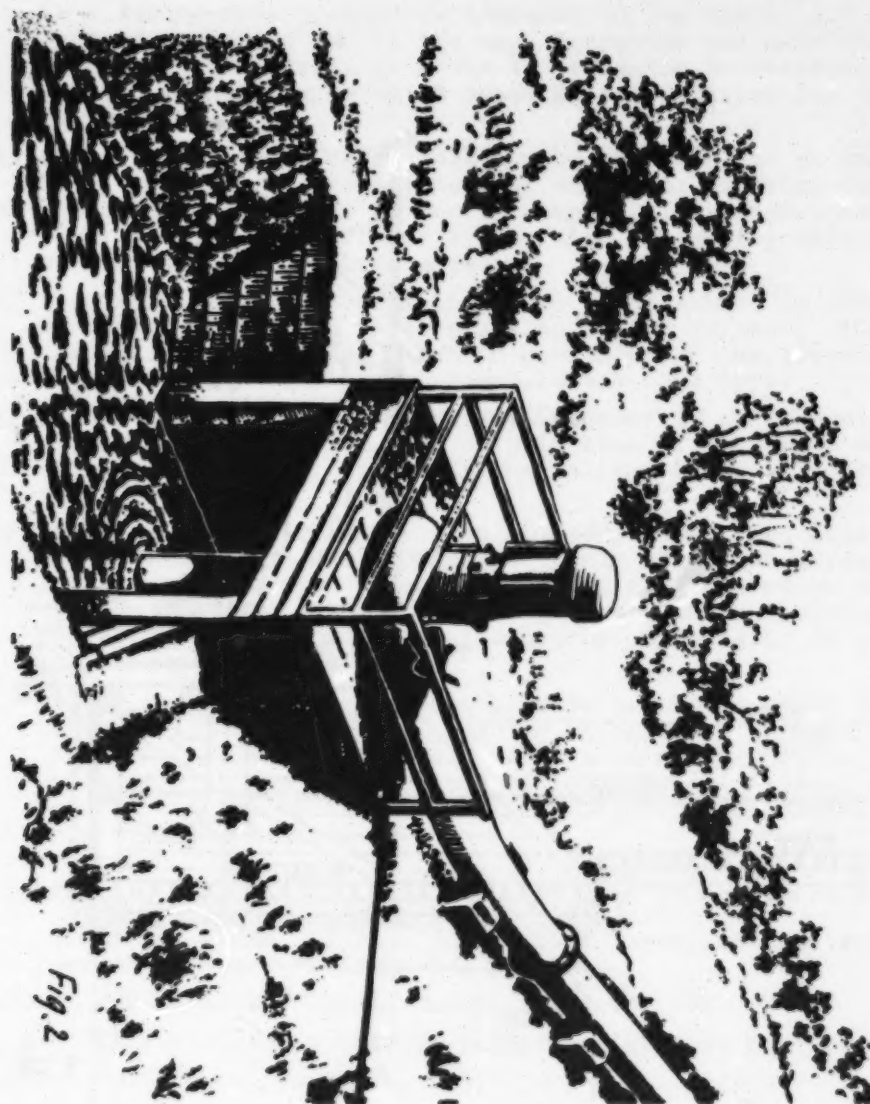
/a/ Low-capacity, mostly 30-100 kW, individual small power plants should be erected.

- /b/ Power plants should, possibly, be fed from local sources of energy, in order to avoid long-distance fuel transport.
- /c/ Imported machinery should be cheap, therefore mass-produced machines should be procured.
- /d/ It should be borne in mind that the energetic efficiency is a second-rate problem as compared to the simplicity of machine equipment and to the easy operation and maintenance resulting from these. It would be advisable to determine the uniform machine types which could be standardized for this purpose.
- /e/ Electricity supply aggregates should, as a rule, be of the outdoor type, only a protecting roof should be provided for. It would be expedient to design simple, light-roof constructions of aluminium or iron tubes, with a cladding made of corrugated iron or slate sheets.
- /f/ Electric installations of the power plant should be uniformly constructed for a three-phase 400/231 V voltage, with neutral earthings. The electric equipment of the power house should be of a completely closed, metal-clad type.
- /g/ Distribution should be effected, in general, at low-voltage. High-voltage should be used only in case of an output exceeding 200-250 kw, for which the uniform 11-16 kV voltage should be chosen.
- /h/ Low-voltage networks should be erected with tarred poles, exceptionally they may be made of plain wood, but anyway, erected on concrete socles. The use of concrete poles should equally be taken into consideration, weighing durability requirements and economic considerations, especially in countries poor in timber.
- /i/ As for indoor equipment, special care should be taken for contact protection. Therefore, the uniform use of metal-clad insulated cables and encased fittings is advisable. In accordance with the requirements of initial agricultural electrification internationally applicable provisional standards should be elaborated.

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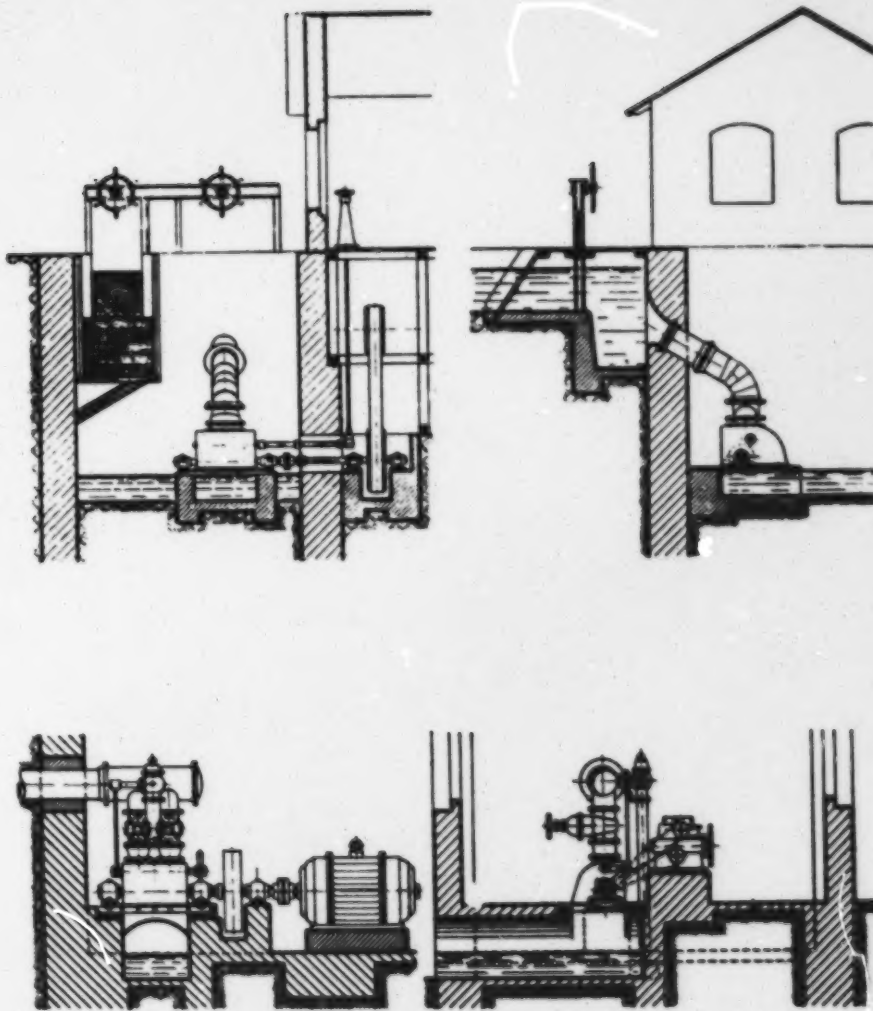


Fig.3



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UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

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THE TECHNIQUE OF PHOTO-INTERPRETATION
FOR MINERAL EXPLORATION

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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

NOTES

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THE TECHNIQUE OF PHOTO-INTERPRETATION FOR MINERAL EXPLORATION

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The geological interpretation of aerial photographs is an important aid in the search for minerals. This method of exploration, therefore, is used in an increasing number of countries and the related techniques are rapidly developing. Photo interpretation has proved its usefulness for mineral exploration in almost every type of terrain, irrespective of the relief, the soil and vegetation cover and the intensity of the land use. The amount of detail that can be obtained varies greatly from one area to another, but everywhere the method has contributed so much to the efficiency of mineral exploration, and thus to the lowering of the cost involved, that a modern exploration project without an elaborate photogeological programme is not warranted.

Mineral Reconnaissance.

Systematic geological reconnaissance is the only sound starting point for a mineral resources inventory. Proper selection of areas of possible economic geological interest is only possible if sufficient data of the regional geology are available. Geological mapping by the conventional field methods, however, is very costly and the area that can be mapped per annum by an average geologist is only limited. Photogeological procedures reduce the amount of necessary field work and thus result in considerable savings. Even more important is the considerable increase in the area that can be mapped per annum and per geologist. The greater accuracy and the substantial amount of additional detail obtained in many areas by photogeological means are a third advantage of the method. For these reasons it is evident that aerial photograph interpretation is one of the important means of coping with the necessity of rapid development of mineral resources in the developing countries.

Adequate coordination of field investigations and the photo-geological studies is an essential prerequisite for obtaining satisfactory results in this first phase of mineral exploration. The customary procedure is to carry out photogeological studies and to prepare a preliminary photo-geological map of the area concerned prior to the field work. The geol-

ogical information existing, such as maps, reports and descriptions of rock samples, is consulted in order to obtain the most reliable results. The areas adjacent to the one under consideration are often included in the study, as there may exist some detailed field data, pertinent to these regions, which may prove most valuable for the correct interpretation of the area studied. Such extrapolation is common practice in photogeology. Another advantage of the inclusion of adjacent areas in the preliminary photogeological studies is that they allow for an understanding of the regional lithological and structural relationships.

The obvious advantages of the preliminary photo interpretation are, amongst others, that the areas of possible economic interest can be selected where subsequent detailed field and air photo studies should be carried out. Extensive areas of little promise can often be indicated where there is no immediate need for carrying out - often expensive - field surveys. All efforts can thus be concentrated on those areas where economic results are more likely. It may even be that phenomena or anomalies are observed on the air photos indicating the occurrence of ore deposits of possible economic interest. It should be borne in mind, however, that this is rather exceptional, that normally the finding of such deposits results from a thorough evaluation of the regional geological studies. Another, not less important advantage of the preliminary interpretation phase is for the planning of the actual field trip. The routes of traverses can be chosen in such a way as to yield a maximum of geological information and a minimum of terrain difficulties. The number of field days is thus kept to a minimum.

Geological photo interpretation has two distinct aspects, viz. the delineation, on the one hand, of boundaries of the various rock formations occurring and on the other the lithological interpretation. The topographical expression of the rock types and formations is the most important indicator for the plotting of these boundaries, because the terrain configuration is the most conspicuous feature to be seen on the air photos. Geomorphology has thus a central position in photogeology. Items of particular interest are, for instance, the pattern and density of the drainage, the cross-sections of valleys and gullies, etc. Vegetation, grey tone and also land use are among other indications which are among other indications which are usually of secondary importance. The lithological interpretation is often fraught with difficulties especially if little or no field information is available and if the photo interpreter has little experience with the type of terrain concerned. In some difficult areas where only a few scattered outcrops occur due to the dense soil and vegetation cover, it may only be possible to delineate areas of similar morphological outlook, so-called photogeological units, without finding sufficiently reliable criteria for the determination of the rock types occurring. The safest approach in such cases is only to delineate and number the various units and to give an accurate description of their photo-characteristics. The determination of the lithology is then left entirely to the field geologist.

The photogeology of areas of igneous and many metamorphic rocks is basically landform mapping, especially in forested areas. The limit to the amount of detail that can then be obtained is determined mainly by the minimum amount of the rock which has to occur for it to develop its characteristic topography. This minimum size depends on the relief, the terrain dissection, etc. and varies largely from one area to another. In areas of sedimentary rocks considerably smaller occurrences can still be correctly interpreted on the strength of their position in the geological structure, even if the characteristic terrain forms are insufficiently, or not at all, developed. More detailed information, therefore, can be generally expected in areas of sedimentary rocks, than in the case with igneous and metamorphic rocks. The scales of the photogeological maps will vary accordingly.

Small scale aerial photographs are the most suitable for this reconnaissance phase of the exploration and the modern super wide angle camera, allowing for photography even on 1:100,000 or 1:125,000 scales, is therefore an invaluable contribution to the rapid inventory of mineral resources. It is claimed, by some authors, that many important de-

tails cannot be distinguished at such small scales and that no satisfactory results can be expected from their interpretation. An answer to this objection, however, is that the amount of detail that can be obtained is not limited by the photo scale, but, as stated above, by the minimum size of a phenomenon needed for the development of the characteristic terrain forms. When interpreting small scale photographs it may be necessary to use the binoculars more frequently, but all necessary details can be derived from them provided that the image sharpness is excellent. Photo quality, therefore, is more critical than in the case of large scale photographs where the image of the various phenomena is larger. At present, because of the prime importance of superior photo quality, the climatic conditions prevailing in the area studied are the limiting factor for the minimum scale of aerial photography for geological purposes. In this respect infra-red emulsions, having a better haze penetration, are important particularly in humid tropical climates.

The advantage of small scale photography for geological reconnaissance is twofold. The larger area which it covers allows a better and quicker understanding of the relations between the various phenomena observed and of the patterns and alignments seen. The second advantage is in the lesser cost of the study and in the shorter time involved. This is due to the fact that both the cost and the speed of a photogeological survey, in much the same way as those of the photographic flight and the photogrammetric procedure, are approximately proportional to the number of photos required to cover the area. For the same purpose of covering a larger area per photograph, trimetrogon aerial photographs were extensively used during and shortly after the second world war, prior to the development of super wide angle photography. Notwithstanding the complications involved in the interpretation of oblique photos, this type of photography proved to be most useful for geological reconnaissance (Verstappen, 1960). This type of photography is at present rather obsolete, but for many remote areas it is often the only photo coverage existing. It should be stressed that even for a medium size project it pays to have new small scale photographs made instead of using an existing large scale coverage.

The field party plan will be based on the preliminary photogeological map. The geologist should take this map and the air photos into the field in order to check the map, to add his field observations and to make corrections if necessary. Improvements of the preliminary map are often possible by stereoscopic study of the air photos in the field camp during and after the investigations on the spot. It is therefore essential that there is an adequate liaison between the photo interpretation studies and the field work. This can best be achieved by having both aspects of the exploration, at least in part, carried out by the same persons. The final maps, compiled after completion of the field work, will serve as a basis for the selection of the more promising areas, where detailed exploration should be carried out.

Subsequent detailed exploration of selected areas.

The reconnaissance phase of exploration described in the foregoing paragraph can largely be avoided in countries where sufficient basic geological data is available. The areas of interest are then determined on the strength of this existing knowledge and the exploration immediately enters the more detailed phase. The photogeological approach to these more detailed studies is rather similar to that of the reconnaissance survey and the same stages, preliminary map-field work-final map, exist. It is often found convenient, however, to use a somewhat larger (medium) photo scale especially in areas where many small details, complicated structures or intricate joint patterns, are to be mapped. The larger number of photos is not a great disadvantage in these cases, because of the more limited size of the selected areas. Special emulsion types are often used with advantage. Much experience has recently been gained with colour aerial photographs for the detection of mineralized zones in arid and other poorly vegetated areas. In densely forested tropical zones their use is more limited and is especially related to exploration for lateritic ores. Research into the use of two layer emulsions and into the most appropriate sensitivity curve of the

emulsion to be selected for a certain project, is particularly promising. The light reflectance of the various rock types occurring in the area is measured by densitometer and the optimum wave length of maximum sensitivity of the emulsion is then chosen accordingly. The interpreter thus benefits fully from minor colour or grey tone differences.

Topography as an indication of the various rock types is also utilized to the full. Particular stress is laid on minor geomorphological features, such as the form of the cross-sections of the valleys and minute erosional features and other characteristics of the hill slopes. The quantitative aspect of photogeology becomes important in this part of the work, especially in oil exploration and other investigations in sedimentary rocks. The measurements include height differences, determination of dip and strike, computation of formational thickness, construction of structural contours, determination of offset along faults, etc. Somewhat more elaborate photogrammetric equipment is sometimes used for these detailed purposes, although most of the problems related to this kind of work can be solved by a good mirror stereoscope with binoculars and a stereometer. In areas of igneous and metamorphic rocks measurement of hill slopes, river gradients and drainage density is sometimes useful for more detailed work. The possibilities for detailed interpretation of the latter types of rock are usually very limited, however, if there is a dense vegetation cover and a larger percentage of the information has then to be obtained during the field survey. In all types of terrain more elaborate field investigations are necessary during the detailed mapping than during the reconnaissance phase of the work and geochemical and geophysical surveys also become more important.

The relation between photogeology and a geophysical survey needs some further consideration. A knowledge of the general geological trend of the area studied is most important for the planning of the geophysical survey, as the survey lines are usually located across the strike. The easiest way to obtain this information is by means of photogeology. The planning of ground geophysical surveys is, furthermore largely influenced by the trafficability of the terrain, information about which can likewise easily be derived from aerial photographs. It is thus evident that in unknown territories a photogeological reconnaissance should precede the geophysical survey so as to decide upon the applicability of this method and for the planning of the survey. During airborne geophysical surveys the actual survey lines are photographed during the flight thus allowing for an accurate location of the geophysical observations by comparing these photos with the overall airphoto coverage. Aerial photographs are thus useful during the planning and the execution of the geophysical survey. Much more important is the aid of photogeology in the correct interpretation of the geophysical data. It should be stressed that geophysical observation usually leaves room for more than one geological interpretation. "Blind" geophysical interpretation, without taking (photo)geological considerations into account, often leads to erroneous conclusions, so that both these methods should obviously go hand in hand.

Location of minerals.

The great variety of ore deposits, such as magmatic hydrothermal, sedimentary, ground water and weathering deposits, accounts for the fact that mineral deposits of economic importance can be expected in many different geological environments. Photogeology is an aid in the search for many of these deposits, but it should be stressed that the method has its distinct limitations. The best results are obtained, of course with mineral deposits which have a characteristic topographic expression. This is the case with a rather small percentage of ore deposits, such as those related to fractures, faults and veins. These linear features are often quite conspicuous from the air and thus can be mapped adequately. Veins often form ridges, the grey tones of which frequently indicate the acidity of the rock type occurring. Another example of topographic expression of lodes is that of weathered outcrops of ore bodies (gossan) which are sometimes easily detected from the air. Mineralization slumping, vegetation differences, etc. are other direct indications of the occurrence of ore bodies. In arid regions leached areas, different in tone from the un-

altered rocks, may be associated with uranium deposits. In the great majority of cases direct evidence for the occurrence of a mineral deposit is lacking, however, and the aerial photographic approach is then different. The photo geological map is used to obtain a detailed insight into the regional geology so as to decide in which areas the chances for mineral accumulation are best. Intrusive bodies, characterized by their irregular topography, are of particular importance in this connection. The contact zone with the surrounding sedimentaries, is usually the most likely location of the mineralization and in many cases mining activity is confined to these belts. Hydrothermal deposits are affiliated to certain host rocks whose permeability or other characteristics favour the formation of economic deposits.

Lateritic ores are another group of mineral occurrences which may well be detected by photogeological means. The laterites are formed on old weathering surfaces and they are characterized by poor vegetation, a usually flat and little dissected surface, and a reddish colour. Iron, manganese, aluminium, nickel, cobalt, etc. may occur as weathering deposits. Examples are the nickel and cobalt deposits of Brasil and New Guinea; and the bauxite of Jamaica.

Photogeology also has proved most valuable in the detection of placer deposits. Interesting results are obtained especially with alluvial deposits (river terraces, etc.) in gold exploration. The correct approach to this problem is to locate the igneous bodies from which the minerals supposedly originate and subsequently to concentrate the search along the rivers draining these source areas. The recent river alluvium and terraces are then mapped and particular attention is paid to outcropping in the river bed or valley of hard rock sills which may have affected the mineral deposition.

Oil exploration has made extensive use of photogeological methods since the 1930's and has given impetus to the development of geological photo interpretation. Qualitative interpretation of the geological structures such as faults, reefs, etc. and quantitative interpretation, such as measurement of strike and dip, structural contouring, etc. are important aspects of this field. Even in areas where the structures are covered by recent or subrecent deposits, the interpretation, based upon the orientation of drainage elements, linear features, etc., yielded remarkable results in some cases. The permeability of the various beds occurring can be estimated on the strength of minor erosional forms, drainage characteristics and vegetation. These indications are particularly useful for the estimation of reservoir.

Photogeological techniques also have been successfully used in relation to hydrogeological studies. Location of aquifers is an important aim in this connection and so is the mapping of fractures faults, dikes, etc. Apart from this geological aspect a knowledge of the climatological, hydrological and morphological situation is essential for the success of these studies so that the percentage of infiltration, surface runoff and evaporation may be estimated.

It is evident from the aforesaid that the technique of geological photo interpretation is a most important aid in all kinds of mineral exploration. It should be borne in mind, however, that it is only one of the tools of modern geology and that a thorough coordination of photogeological, geophysical, geochemical and conventional field investigations is indispensable in obtaining adequate results.

Literature.

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[The body of the document contains several paragraphs of extremely faint, illegible text. The text appears to be a formal report or memorandum, possibly detailing a project or organizational structure. Due to the low contrast and quality of the scan, the specific words and sentences cannot be transcribed.]



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**CONFÉRENCE DES NATIONS UNIES
SUR L'APPLICATION DE LA SCIENCE ET DE LA TECHNIQUE
DANS L'INTÉRÊT DES RÉGIONS PEU DÉVELOPPÉES**

Point de l'ordre du jour : A.3.1.1

Yougoslavie

**L'ESTIMATION DES RESSOURCES D'EAU EXISTANTES
ET LEUR UTILISATION A DIFFÉRENTES FINS**

Par Bozidar NESOVIC,
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Les mémoires rédigés à l'intention de la Conférence des Nations Unies sur l'application de la science et de la technique dans l'intérêt des régions peu développées sont des documents de travail. Ils sont publiés tels qu'ils ont été présentés et les assertions et opinions qu'ils contiennent sont celles de leurs auteurs.

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L'ESTIMATION DES RESSOURCES D'EAU EXISTANTES

ET LEUR UTILISATION A DIFFERENTES FINS

p a r

Ing. Božidar Nešović, conseiller à l'Institut des eaux "Jaroslav Černi",
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1. Le terme "ressources d'eau" comprend les eaux disponibles dans une région donnée qui peuvent être utilisées pour satisfaire aux besoins de l'homme et de l'économie. Ces ressources représentent la condition fondamentale de l'évolution de la vie et du développement de la région.
2. L'ampleur et le caractère des ressources dépendent des conditions naturelles de cette région.
3. L'exploitation adéquate des ressources d'eau exige leur connaissance complète avec toutes les caractéristiques principales incluses.
4. La connaissance des ressources d'eau exige un long travail continu. Il exige des organisations spéciales dont la tâche serait la contemplation permanente, le rassemblement des données, les études et la découverte des solutions les plus favorables dans l'utilisation des ressources d'eau.
5. Dans les régions économiquement développées ce travail est exécuté depuis des dizaines d'années de la part des organisations professionnelles permanentes ou temporaires en collaboration avec des différents experts. Même dans les cas où les ressources d'eau sont suffisamment étudiées et élaborées, les études de leur utilisation mettent en évidence le besoin des travaux supplémentaires afin d'utiliser ces eaux de manière la plus rationnelle.
6. Le travail qu'exigent l'exploration et l'utilisation des ressources d'eau peut en grandes lignes être divisé en 4 phases.
7. La première phase englobe l'exploration générale des ressources d'eau, l'organisation et le rassemblement des données nécessaires aux postérieures études hydrologiques et économiques.
8. La deuxième phase englobe le recensement des capacités des ressources d'eau utilisées et non-utilisées avec les installations construites sur elles ou liées à elles.
9. La troisième phase englobe la planification perspective dans le domaine de l'économie des eaux, notamment l'élaboration des bases de l'économie des eaux.
10. La quatrième phase englobe l'utilisation concrète des ressources d'eau pour des fins économiques et autres.
11. Les études des ressources d'eau se poursuivent ordinairement parallèlement et proportionnellement avec le développement de l'économie de la région. Dans les régions économiquement très avancées, toutes les phases de la détermination des ressources d'eau sont pratiquement terminées, dans les régions peu ou insuffisamment développées ces phases sont en cours d'élaboration, tandis que dans les régions sous-développées ce travail est dans la phase initiale.
12. Dans nos considérations suivantes nous tiendrons compte des régions économiquement peu ou sous-développées.

13. Le rassemblement et la systématization des données sont confiés aux services hydrométéorologiques qui le plus souvent font part de l'administration d'Etat. Les ressources d'eau ne peuvent être exactement évaluées et déterminées sans un nombre suffisant de données assurées par le service hydrométéorologique. Par conséquent, l'organisation et le fonctionnement régulier de ce service dans le domaine de l'économie des eaux doivent être traités de devoirs primordiaux.

14.-Le travail exécuté dans les régions développées présente une expérience précieuse pour l'organisation et le fonctionnement de ce service. L'application de ces expériences dans les régions sous-développées exige l'adaptation de l'organisation et du travail de ce service en fonction du temps et de l'ampleur de leur développement économique et des possibilités techniques qui assureraient le succès de la tâche.

15. Les données hydrométéorologiques et les calculs théoriques permettent de passer à la deuxième phase qui englobe l'élaboration de l'étude hydrologique destinée à déterminer et définir les capacités des ressources d'eau. Les résultats de ces études sont rangés et systématisés dans le cadastre d'eau.

16. Le devoir du cadastre d'eau est de présenter clairement l'état naturel et les caractères des ressources d'eau, ainsi que les moyens et le degré de l'exploitation au moment de l'instauration du cadastre et enfin de présenter les principaux éléments hydrologiques et autres pour faciliter leur exploitation future.

17. Les cadastres d'eau servent de base pour une juste planification et exploitation des ressources d'eau conformément aux besoins de l'économie et des agglomérations.

18. La troisième phase du travail englobe l'élaboration des bases de l'économie des eaux. Les données rangées dans les cadastres d'eau servent de base pour l'étude des possibilités d'exploitation des ressources d'eau à diverses fins qu'exigent les différentes branches économiques et les besoins communaux de la région. Ces possibilités sont présentées de meilleure manière, classifiées selon les besoins du développement économique et enfin y sont données les recommandations et les solutions pour la plus rationnelle utilisation des ressources d'eau conformément au probable développement perspectif. Cette base de l'économie des eaux ainsi élaborée présente un fond concret pour l'utilisation planifiée des ressources d'eau, elle facilite le choix favorable des installations qui doivent être érigées et en même temps elle offre des facilités aux organes compétents de l'administration d'Etat pour apporter de justes décisions concernant la planification et le consentement se rapportant à l'utilisation des ressources d'eau.

19. La quatrième et dernière phase comprend l'élaboration des projets et la construction des installations pour l'exploitation des ressources d'eau.

20. Si toutes les phases des recherches des ressources d'eau sont étudiées, alors on peut entreprendre sans difficulté et danger d'erreurs la plus favorable exploitation des ressources d'eau et rationnellement élaborer les projets ainsi qu'exécuter la construction des installations correspondantes.

21. Analysant le processus et les phases du travail concernant l'étude et l'exploitation des ressources d'eau que nous venons de citer, on remarque que ce travail présente un procédé long et complexe. Il exige la création des organisations professionnelles, l'engagement d'un grand nombre d'experts hautement qualifiés pour un long période et tout dans le but d'assurer la plus rationnelle exploitation des ressources d'eau. Cependant, le rapide développement économique et social exige d'aborder promptement une plus ou moins ample exploitation des ressources d'eau. C'est pourquoi il est indispensable, lors de l'exploitation des ressources d'eau, de procéder attentivement et avec élasticité selon les besoins du développement économique, ne gaspillant pas les ressources.

22. Si les intérêts de l'économie imposent une prompte exploitation des ressources d'eau, sans suffisantes études et données, l'exploitation est alors pratiquée sur la base des estimations approximatives avec un certain risque à commettre des fautes plus ou moins graves au détriment d'une rationnelle exploitation des ressources. Ces fautes possibles peuvent quelquefois être éliminées plus tard, mais dans ces cas l'exploitation rapide des ressources d'eau, même incomplète, est plus avantageuse pour le développement de l'économie qu'un retardement qui assurerait une exploitation parfaite.

23. Le domaine et le mode de l'exploitation des ressources d'eau sont très amples et variés.

24. Les principaux domaines de l'exploitations sont: besoins communaux, irrigation, approvisionnement de l'industrie dans différents procédés technologiques, production de l'énergie électrique, navigation etc.

25. L'organisation et les méthodes de travail dans les recherches et l'exploitation des ressources d'eau dans les régions moins développées dépendent des réelles possibilités pour l'exécution du procédé mentionné et de l'engagement des cadres professionnels. A cause de cela, à part les principes déterminés dont il faut se tenir pendant le travail, il est impossible de fixer un schéma pour l'organisation et le travail qui conviendraient à toutes les régions.

26. Lors de l'organisation et le choix des méthodes de travail il faut s'accommoder aux conditions qui existent dans chaque région. Il faut souligner l'importance de l'organisation et des méthodes de travail adéquates, car dans ce domaine il arrive souvent que malgré un long travail et les moyens sacrifiés on n'obtienne des résultats attendus qui pourraient être favorablement utilisés. C'est pourquoi l'organisation et l'exécution de ce travail exige l'engagement des experts ayant une grande expérience dans ce domaine.

27. Les principes et les recommandations que nous venons de citer sont basés pour la plus grande part sur les expériences acquises au cours du travail en Yougoslavie en tenant compte des résultats du même travail exécuté dans les régions développées dans tout le monde. A cause de cela il y a intérêt de montrer en lignes générales les expériences obtenues en Yougoslavie au cours de la détermination et exploitation des ressources d'eau.

28. Le travail de rassemblement des données pour déterminer les ressources d'eau a pratiquement commencé après la première guerre mondiale. On a créé la Direction des eaux qui a organisé le service hydrométéorologique plus ou moins important sur tout le territoire de la Yougoslavie.

29. Entre les deux guerres l'exploitation des ressources d'eau a été médiocre. La possibilité de leur exploitation pour des fins hydroénergétiques a été partiellement étudiée de la part de certains experts, notamment quand des compagnies étrangères ont montré leur intérêt pour l'investissement et l'exploitation.

30. Après la fin de la deuxième guerre mondiale et la libération de la Yougoslavie un des premiers devoirs, à part la reconstruction des installations détruites pendant la guerre, était l'élaboration et l'approbation du premier plan quinquennal du développement économique et social. Ce plan prévoit l'exploitation intense des ressources d'eau et parallèlement le rassemblement des données insuffisantes et la détermination des ressources d'eau.

31. Le brusque développement économique et le manque des cadres professionnels ne permettaient pas des études suffisantes pour distinguer les plus favorables possibilités d'exploitation des ressources d'eau, surtout pour des fins hydroénergétiques. Le résultat en a été que le choix de certaines installations pour l'exploitation des ressources d'eau n'a pas été le plus favorable comparé aux ressources d'eau ultérieurement déterminées et approuvées.

32. Par l'intermédiaire de particulières organisations scientifiques et techniques on a continué de rassembler les données et d'exécuter les recherches scientifiques dans ce domaine. En même temps on a découvert et déterminé presque toutes les ressources d'eau du pays, de sorte que dans les suivants plans économiques on évitait de plus en plus les erreurs et défauts antérieurs.

33. Nous pouvons prétendre que de nos jours toutes les ressources d'eau du pays sont plus ou moins découvertes et évaluées ce qui sert de base pour la planification des investissements dans le domaine de l'économie des eaux conformément au développement des autres branches économiques et de la vie dans le pays.

34. La phase actuelle du travail concernant l'exploitation des ressources d'eau comprend essentiellement le travail des recherches scientifiques et de l'élaboration des projets rattachés à la quatrième phase, afin de remarquer et d'élaborer les projets pour les plus rationnels investissements et installations qui permettraient leur utilisation conformément aux plans du développement économique.

35. Les experts ont été souvent d'avis qu'il fallait éviter l'exploitation des ressources d'eau avant des études approfondues et la détermination des modes les plus favorables de leur exploitation. Cependant, l'idée prédominante a été qu'une prompt exploitation des ressources d'eau, même insuffisamment étudiée et contenant de petits défauts, servait mieux les intérêts de l'économie qu'une longue attente nécessaire pour déterminer complètement les ressources d'eau et leur plus-rationnelle utilisation.

36. Les erreurs originaires, commises au cours d'un rapide développement économique de la région, peuvent être éliminées au cours du procédé ultérieur du travail par une favorable organisation du travail par phases dans le but de déterminer les ressources d'eau, comme nous l'avons déjà mentionné.

37. Se basant sur ces expériences l'opinion qui a été mise en évidence est que lors de la détermination et l'exploitation des ressources d'eau il faut suivre les phases et les principes mentionnées, mais en même temps tenir compte des intérêts et de la dynamique du développement économique et social de la région.

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